

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

**THE SHORTER
SCIENCE AND CIVILISATION IN CHINA**

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

COLIN A. RONAN

The Shorter Science and Civilisation in China

AN ABRIDGEMENT OF

JOSEPH NEEDHAM'S ORIGINAL TEXT

Volume 2

VOLUME III AND A SECTION OF
VOLUME IV, PART I
OF THE MAJOR SERIES

MATHEMATICS

ASTRONOMY

METEOROLOGY

GEOGRAPHY & MAP-MAKING

GEOLOGY & RELATED SCIENCES

PHYSICS (excluding electricity & magnetism)



**CAMBRIDGE
UNIVERSITY PRESS**

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011-4211, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© Cambridge University Press 1981

First published 1981
First paperback edition 1985
Reprinted 1992, 1995

British Library cataloguing in Publication Data

Ronan, Colin Alistair
The shorter 'Science and civilisation in China', Vol. 2
1. Science – China – History
2. Technology – China – History
I. Title II. Needham, Joseph. Science and civilisation
in China. *Adaptations*
509'.51 QC127.C5 80-40784
ISBN 0 521 23582 0 hardback
ISBN 0 521 31536 0 paperback

Transferred to digital printing 2000

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)**CONTENTS***List of Illustrations vi List of Tables x Preface xi*

1	Mathematics	1
2	The sciences of the heavens: (i) Astronomy	67
3	The sciences of the heavens: (ii) Meteorology	222
4	The sciences of the earth: (i) Geography and map-making	237
5	The sciences of the earth: (ii) Geology and related sciences	286
6	Physics	325
	Table of Chinese dynasties	388
	Bibliography	389
	Index	394

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

ILLUSTRATIONS

-
- | | | | |
|----|---|----|---|
| 30 | Proof of Pythagoras' Theorem: 8 | 49 | Diagram illustrating problems in spherical trigonometry, A.D. 1600: 45 |
| 31 | The problem of the Broken Bamboo: 10 | 50 | Diagram to illustrate the spherical trigonometry of Kuo Shou-Ching, A.D. 1276: 45 |
| 32 | Liu Hui's method of finding π by an exhaustion process: 12 | 51 | 'The puzzle of the Linked Rings': 46 |
| 33 | Measurement of the height of a pagoda: 13 | 52 | 'The 'matrices' of the <i>Thien Yun</i> method of writing terms in algebra: 53 |
| 34 | Determination of the diameter and circumference of a walled city by observations from outside: 14 | 53 | 'The 'Pascal' Triangle, A.D. 1303: 55 |
| 35 | A problem in dyke construction: 14 | 54 | Integration of thin rectangles for measuring the area of a circle: 59 |
| 36 | Two magic squares, A.D. 1593: 20 | 55 | Rectangles inscribed within a circle: 60 |
| 37 | The Lo Shu diagram: 21 | 56 | The circles of the celestial sphere: 70 |
| 38 | The Ho Thu diagram: 21 | 57 | The Arabic system of coordinates: 71 |
| 39 | A magic square of A.D. 1275: 22 | 58 | Diagram of circumpolar stars: 73 |
| 40 | The construction of a magic square: 23 | 59 | The legend of Hsi and Ho: 74 |
| 41 | A three-dimensional magic square, c. A.D. 1880: 24 | 60 | Reconstruction of the Kai Thien cosmology: 83 |
| 42 | Diagram of A.D. 1261 to illustrate extraction of a square root: 27 | 61 | The stars of the Great Bear (Ursa Major): 93 |
| 43 | A view of a counting-board: 29 | 62 | Diagram to illustrate the keying of circumpolar with other stars: 94 |
| 44 | The Chinese form of Napier's rods: 31 | 63 | The Great Bear carrying one of the celestial bureaucrats: a tomb-shrine relief: 102 |
| 45 | A Chinese slide-rule of A.D. 1660: 32 | | |
| 46 | A Chinese abacus: 33 | | |
| 47 | An early printed picture of the abacus: 34 | | |
| 48 | Practical derivation of the solid geometry of sections of pyramids: 42 | | |

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)*List of illustrations*

vii

- | | | | |
|----|--|-----|---|
| 64 | Oracle-bone inscription which mentions Bird-Star, c. 1300 B.C.: 103 | 84 | Bronze TLV mirror from the Hsin dynasty: 140 |
| 65 | Bronze mirror of the Tang period showing constellation diagrams of the 28 <i>hsiu</i> : 105 | 85 | A scene depicting magician-technicians at work: 141 |
| 66 | Chart of the <i>hsiu</i> : 106 | 86 | A scene of two men playing a game at a table: 141 |
| 67 | Symbolism of the dragon and the moon: 110 | 87 | Plane sundial of the Former Han period: 142 |
| 68 | Fragment of Babylonian planisphere: 111 | 88 | Inscriptions on the plane sundial of Fig. 87: 143 |
| 69 | Polar projection showing ancient pole-stars: 113 | 89 | Reconstruction of mode of operation of plane sundial of Fig. 87: 144 |
| 70 | A time-exposure photograph of circumpolar stars: 114 | 90 | Late Chinese portable sundial, type <i>A</i> : 146 |
| 71 | Diagram of celestial coordinates: 117 | 91 | Late Chinese portable sundial, type <i>B</i> : 146 |
| 72 | Han stone carving showing the Weaving Girl constellation: 122 | 92 | Late Chinese portable sundial, type <i>C</i> : 148 |
| 73 | Constellations on Taoist flag: 122 | 93 | Types of Chinese clepsydras or water-clocks: 150 |
| 74 | The Tunhuang manuscript star-map of c. A.D. 940; polar projection: 123 | 94 | Clepsydra with four compensating water tanks: 153 |
| 75 | The Tunhuang manuscript star-map of c. A.D. 940; 'Mercator' projection: 124 | 95 | Overflow type of clepsydra, A.D. 1030: 154 |
| 76 | The star-maps for the celestial globe in the <i>Hsin I Hsiang Fa Yao</i> of A.D. 1092: 125 | 96 | Oldest printed picture of a clepsydra, c. A.D. 1155: 156 |
| 77 | The Suchow planisphere of A.D. 1193: 126 | 97 | Metal incense clock: 157 |
| 78 | Measurement of the sun's shadow at the summer solstice: 131 | 98 | Chinese sighting-tube and quadrant: 160 |
| 79 | Ancient and medieval measurements of the obliquity of the ecliptic: 132 | 99 | Medieval Western sighting-tube: 161 |
| 80 | The tower of Chou Kung at Yang-chhêng for measurements of the sun's shadow at the solstices: 135 | 100 | The ancient ritual objects of jade, <i>pi</i> and <i>tshung</i> : 162 |
| 81 | The tower of Chou Kung at Yang-chhêng looking along the shadow scale: 136 | 101 | Use of the circumpolar constellation template: 163 |
| 82 | The tower of Chou Kung at Yang-chhêng looking down the shadow scale: 137 | 102 | Equatorial armillary sphere in Chinese tradition set up at Peking Observatory, A.D. 1744: 165 |
| 83 | TLV designs on mirrors and divination boards: 139 | 103 | Smaller equatorial armillary sphere of Tycho Brahe, A.D. 1598: 166 |
| | | 104 | Equatorial armillary sphere of Kuo Shou-Ching: 167 |
| | | 105 | Su Sung's armillary sphere: 168 |
| | | 106 | The torquetum of Apianus: 175 |

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)*List of illustrations*

viii

- | | | | |
|-----|--|-----|--|
| 107 | The 'simplified instrument' or equatorial torquetum of Kuo Shou-Ching seen from the south-east: 176 | 125 | Diagrammatic chart of the river systems of West China, c. A.D. 1160: 247 |
| 108 | Diagram of Kuo Shou-Ching's equatorial torquetum seen from the south-east: 177 | 126 | Panoramic map from the <i>Hsing Shui Chin Chien</i> , A.D. 1725: 248 |
| 109 | Kuo Shou-Ching's equatorial torquetum from the south: 178 | 127 | Ptolemy's world map as reconstructed by the Venetian Ruscelli, A.D. 1561: 254 |
| 110 | Twentieth-century equatorial telescope mounting: 179 | 128 | World map of the type due to Beatus Libaniensis (<i>d.</i> A.D. 798): 254 |
| 111 | Su Sung's celestial globe rotated by water-driven mechanical clock: 182 | 129 | Diagrams to illustrate chief forms of the European tradition of religious cosmography: 255 |
| 112 | A late Chhing representation of the Nine Roads of the Moon: 185 | 130 | Schematised world map of Isodore of Seville (A.D. 570 to 636): 257 |
| 113 | Chart showing the retrograde motion of Mercury: 189 | 131 | The universe according to <i>Christian Topography</i> by Cosmos Indicopleustes, c. A.D. 540: 257 |
| 114 | Lunar eclipse: 195 | 132 | Spain on the portolan chart of Angelino Dulcerto, A.D. 1339: 258 |
| 115 | Total solar eclipse: 196 | 133 | Reconstruction of the <i>shih</i> or diviner's board of Han times: 263 |
| 116 | The oldest record of a nova, c. 1300 B.C.: 206 | 134 | Early attempt at contour mapping: 265 |
| 117 | Drawing of a comet, October 1664, from the Korean Astronomical Bureau: 209 | 135 | The <i>Yü Chi Thu</i> (Map of the 'Tracks of Yü the Great): 266 |
| 118 | The Peking Observatory, c. A.D. 1925: 219 | 136 | Two pages from the <i>Kuang Yü Thu</i> (Enlarged Terrestrial Atlas): 268 |
| 119 | Manuscript illustrations of parhelia by the emperor Chu Kao-Chih, c. A.D. 1425: 229 | 137 | Key to the symbols in the <i>Kuang Yü Thu</i> : 269 |
| 120 | The bore on the Chhien-Thang River near Hangchow: 234 | 138 | One of the sea-charts from the <i>Wu Pei Chih</i> : 271 |
| 121 | The traditional idea of the way Chinese culture radiated from its imperial centre: 239 | 139 | Arabic wheel-map of the tenth century A.D.: 272 |
| 122 | Representations of fabulous beings from the <i>Shan Hai Ching</i> (sixth century B.C. to first century A.D.) and <i>Collectanea Rerum Memorabilium</i> (third century A.D.): 240 | 140 | The world map of al-Ṭūsī: 273 |
| 123 | Barbarian envoys presenting tribute at the Hung Lu Department: 243 | 141 | Chinese survey methods, A.D. 1044: 276 |
| 124 | Two pages from the <i>I Yü Thu Chih</i> (Illustrated Record of Strange Countries), c. A.D. 1430: 244 | 142 | Illustration of survey geometry for measuring the height of a crag: 277 |
| | | 143 | The use of Jacob's Staff, A.D. 1556: 278 |
| | | 144 | Two kinds of vessel from which the earliest relief maps may have originated: 281 |

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)*List of illustrations*

ix

- | | |
|--|--|
| <p>145 Geology in Chinese art: (a) the rejuvenation of a valley at Li-Shan in Shantung: 287</p> <p>146 Geology in Chinese art: (b) deposit of water-rounded boulders at I-Shan in southern Shantung: 287</p> <p>147 Geology in Chinese art: (c) an exposed anticlinal arch at Lung-Mien Shan in Anhui: 288</p> <p>148 Geology in Chinese art: (d) the eroded cliffs of Yen-Tang Shan on the coast of southern Chekiang: 289</p> <p>149 Stalactites, stalagmites and crystal-line deposits: 294</p> <p>150 Drawings of fossil animals, A.D. 1596: 298</p> <p>151 An attempted reconstruction of the mechanism of Chang Hêng's seismograph: 303</p> <p>152 Another attempted reconstruction of the mechanism of Chang Hêng's seismograph, using the principle of the inverted pendulum: 304</p> <p>153 A third attempted reconstruction of the mechanism of Chang Hêng's seismograph, also using the principle of the inverted pendulum: 305</p> | <p>154 Evaporator of traditional type at the Tzu-liu-ching brine field: 310</p> <p>155 Collection of water-worn jade nuggets by women and girls, A.D. 1637: 319</p> <p>156 Rotary tools for working jade: 320</p> <p>157 Tentative reconstruction of an 'advisory vessel': 335</p> <p>158 A 'magic mirror' of Japanese provenance: 354</p> <p>159 Diagrammatic cross-section of a 'magic mirror': 355</p> <p>160 Image of Kuan-Yin of the Four Cardinal Points and the Thousand Arms: 363</p> <p>161 A late Chhing representation of the instruction of musicians by the legendary music-master Hou Khuei: 369</p> <p>162 The <i>chhun</i>, a bronze bell of elliptical section: 377</p> <p>163 Clapperless upward-facing hand-bell: 378</p> <p>164 Clapperless downward-facing hand-bell: 379</p> <p>165 Chu Tsai-Yü's tuning instrument: 386</p> |
|--|--|

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

TABLES

- | | | | |
|----|--|----|--|
| 19 | Ancient and medieval Chinese numerical signs: 2 | 31 | The 24 fortnightly periods (<i>chhi</i>): 192 |
| 20 | Notations for numerals higher than 10 on the Shang oracle-bones and on Chou bronze inscriptions: 6 | 32 | Observations of solar eclipses by ancient Chinese astronomers: 201 |
| 21 | Types of numbers: 19 | 33 | Chart to show comparative development of astronomy in East and West: 220 |
| 22 | Table of the <i>hsiu</i> ('lunar mansions', equatorial divisions, or segments of the celestial sphere bounded by hour-circles): 96 | 34 | Correlation of severe winters with sun-spot frequency: 225 |
| 23 | Stars referred to in column 8 of Table 22: 100 | 35 | Ratio of droughts to floods by centuries: 228 |
| 24 | Breakdown of star totals in ancient star lists: 115 | 36 | Chart to show comparative development of cartography in East and West: 284 |
| 25 | Probable dates of observations in the star-catalogues: 116 | 37 | The coverage of stones and substances in Western and Eastern lapidaries: 312 |
| 26 | Relation between occidental constellations and Chinese star groups: 120 | 38 | Data of the Meridian Arc Survey of I-Hsing and Nankung Yüeh (A.D. 724 to 726): 338 |
| 27 | Some occidental constellations and Chinese star groups: 121 | 39 | Li Shih-Chen's classification of the varieties of fire: 345 |
| 28 | Evaluation of the fraction of the tropic and sidereal year: 134 | 40 | Traditional list of the eight sources of sound: 371 |
| 29 | Values for the length of the lunation: 183 | 41 | Classification of the bells in the <i>Kuo Yü</i> : 373 |
| 30 | Estimates of periods of planetary revolutions: 188 | | |

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

PREFACE

With the second volume of the abridgement of Dr Joseph Needham's *Science and Civilisation in China* we start to look in some detail at the Chinese contributions to various sciences. Beginning with mathematics, written with the non-mathematical reader in mind, the text is next concerned with the sciences of the heavens – astronomy and meteorology (which was also considered a celestial subject in ancient times). The sciences of the earth follow next – geography and map-making, with geology and its allies, seismology and mineralogy. Finally there is a description of some, though not of all, Chinese physics – their predilection for wave theory as opposed to particles, their work in measurement, their studies of statics and hydrostatics, of motion, surface phenomena, heat, light and sound – and a note on the invention of the tempered scale, almost contemporary in China and Europe. This volume therefore covers what is in volume 3 of *Science and Civilisation in China* and about half the content of volume 4, part 1.

Once again I have been encouraged and helped by Joseph Needham, who has always been very ready with advice and has generously given of his valuable time to read critically through these pages. For this I am most grateful. As before this is no new edition; it is an abridgement of the original text. Nevertheless we have made a few minor changes here and there because time has brought further insight into some questions. On magic squares, however, we do not find much need for revision in spite of the criticisms of Schuyler Cammann, but anyone wishing to go further into the matter should certainly read what he has written on the subject. Again, Geneviève Guitel's discussion of our views on the Shang numerical system does not call for any major alterations, though interested readers may well wish to refer to her careful discussion of number systems in general. Nor have we altered the original translations of the Mohist canon, even though specialists will assuredly need to follow Angus Graham's new translations. Lastly, it is necessary to draw the attention of the reader to the work of

Cambridge University Press

978-0-521-31536-4 - The Shorter Science and Civilisation in China: An Abridgement
of Joseph Needham's Original Text, Volume 2

Colin A. Ronan

Frontmatter

[More information](#)

Preface

xii

Yabuuchi Kiyoshi on the Chinese calendar-systems or astronomical tables and of Nathan Sivin on the history of Chinese mathematical astronomy. A note of all these works will be found in the bibliography, which has been generously compiled by Joseph Needham and Nathan Sivin.

The romanisation adopted is the same as that in volume 1; i.e. the system of Wade-Giles, with the substitution of *h* for the aspirate apostrophe (see Table 1 in volume 1 of this abridgement).

My warm thanks are also due to the Press editor, Dr Simon Mitton, for his patience, and to their copy editor for her immense care. I owe a debt of thanks, too, to Mrs Shirley Barry who has typed the manuscript so ably, and to my wife, Penny, for reading carefully through all my text and making some very helpful comments. I am indebted, too, to Mr Storm Dunlop for reading proofs, and to Miss Muriel Moyle for compiling the index.

Bar Hill, Cambridge
2 February 1980

Colin A. Ronan