. . . AND THEIR INSTRUMENTS

M. J. T. Lewis: *Surveying Instruments of Greece and Rome*. Pp. xx + 389, ills. Cambridge: Cambridge University Press, 2001. Cased, £55. ISBN: 0-521-79297-5.

This much-needed account of Greek and Roman surveying instruments fits in well with recent interest in ancient technology, in particular mathematics, measurement, surveying, aqueduct construction, and hydraulic engineering. Lewis has written an excellent book, which will be useful to classical scholars and to anyone with a general interest in the ancient world and the history of technology. It is clearly written, and contains many succinctly expressed and sensible ideas that contribute to an integrated study which brings together surveying instruments, their practical application, and the relevant ancient texts in translation. Well-chosen diagrams and photographs assist L.'s interpretations, and he is always careful to signpost speculative conclusions.

Part One deals with the origins, purpose, and method of operation of the most important surveying instruments. The Greeks principally used the *dioptra*, which measured angles, distance, and heights in both horizontal and vertical planes. It consisted of a disc engraved with two diameters at right angles and a sighting bar, and L. discusses a reconstructed version. One of its most important uses was for levelling, the process by which differences in height between two or more places can be determined. L. argues that it was sufficiently accurate to deal with the typically steep Greek aqueduct. Hero's version of the *dioptra* (pp. 82–9), which is very elaborate, was probably an attempt at improving the simple original model. The *libra*, which was possibly developed from the sighting tube, perhaps with some Greek influence, was a Roman instrument, but evidence is very limited since Vitruvius is the only Roman writer to mention it. It was more accurate than the *dioptra* because of a reduced tendency to swing in the wind. It was used in the vertical plane principally for the levelling of aqueducts. L. again uses a reconstructed version to assist his interpretation. The *groma* was the main instrument of Roman land surveyors, and was used mainly in the horizontal plane to measure distance and angles. This theme perhaps deserves more detailed treatment, not least because the Roman land surveyors have provided our largest source of information for ancient surveying in the *Corpus Agrimensorum Romanorum*. In particular, we should hear more about how the *groma* was used for levelling. L. cites (p. 125) a passage of Frontinus, but does not include it or other related material in the list of translated sources in Part Three. This section of Frontinus is notoriously difficult to interpret. Nevertheless, it is a rare indication of how the Romans measured not only valleys too wide to sight across but also rough terrain adjacent to centuriated areas. L. provide a useful discussion on the problems of reconstructing the *groma*, and deals with recent attempts to reassess the fundamental work of Della Corte on the fragments of a surveying instrument found at Pompeii. Finally, L. briefly examines the hodometer, which measured distance travelled. Another device with its origin in Greece was the *chorobates* (literally 'land-pacer'), which seems, however, to have served largely as a kind of builder's level, and had no significant rôle in surveying.

Part Two deals with the practical applications of the instruments, in respect of the measurement of the earth, calculating the heights of mountains, the laying out of canals and aqueducts, and the building of tunnels and roads. L.'s analysis of the surveying of aqueducts is particularly valuable (pp. 170–96). The ancient world normally relied on gravity for the passage of water. Roman aqueducts had shallower

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gradients than Greek ones, and this suggests good levelling techniques by surveyors, who probably used the *libra*. The difficulty is that water flows fast and shallow on a steep gradient, and on meeting a gentler decline slows down and backs up, and may possibly overflow (p. 185). L. provides a fascinating examination of how the ancient surveyors overcame the problems of the aqueduct at Nîmes, with its extremely shallow gradient. There is also an excellent discussion of the building of Roman roads (pp. 217–45). The best-known feature of the roads is their straightness, and the intriguing question is how long, straight alignments were laid out. Surveying writers have little to say about road building, so most of the evidence comes from the roads themselves. The surveyors mainly used the *groma* and there were three stages: reconnoitre the land between the endpoints, mark out a straight line or an alternative between the endpoints, and work out the route in detail on the ground. L. considers the various possibilities for establishing long-distance alignment and his preferred solution is extrapolation from one fixed point based on the geometry of similar triangles (p. 232). He also notes that we should not suppose that all long alignments were laid out in the same way. For example, the Fosse Way was not a single road but a succession of short roads built to connect military installations. This sensible discussion is a salutary warning against elaborate theories for the layout of Roman roads. An epilogue to this section briefly considers parallels in other civilizations to Greek and Roman surveying instruments, and assesses the degree of continuity in surveying practice through the Sasanids in Persia, Byzantium, and Islam, after the fall of the Roman Empire in the West.

Part Three sets out translations of extracts from the relevant ancient sources, including Greek, Latin, Hebrew, Syriac, and Arabic texts. These are clearly expressed and usefully complement the discussion in the preceding sections.

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AQUEDUCTS

D. R. Blackman, A. T. Hodge (edd.): *Frontinus' Legacy: Essays on Frontinus'* De Aquis Urbis Romae. Pp. xi + 170, ills. Ann Arbor: The University of Michigan Press, 2001. Paper, £12.50. ISBN: 0-472-06793-1 (0-473-09793-8 hbk).

For some decades, the study of ancient water supply has attracted a lot of scholarly attention from various disciplines. This book aims to be an interdisciplinary study of Frontinus' work, and intends to address the questions that lie between the lines of his text. The editors—one (Hodge) trained in classics, the other (Blackman) in mechanical engineering—have been engaged in this field before. Together they have written the major part of the book under discussion.

What do the editors mean by 'Frontinus' legacy'? Frontinus, *curator aquarum* in Rome in A.D. 97, has written the only treatise on water supply that is left to us from antiquity. For this reason, his *de aquis urbis Romae* is referred to in almost every study on Roman water supply. A clear answer to the question about the meaning of the book title is given in Chapter 12, 'Epilogue', p. 153, where Frontinus' true legacy is specified as 'Roman engineering and society'.

In the introductory chapter the reader is informed that the main issues raised in the book are techniques, capital, and labour. In addition, the gross parameters of the

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