Wheelwrights of the heavens

A. W. Sleeswyk

Geared to the Stars: The Evolution of Planetariums, Orreries and Astronomical Clocks. By H. C. King, in collaboration with J. R. Milburn. Pp. 442. (Adam Hilger: Bristol, 1978.) £25.

In twenty-one chapters and over 366 pages, illustrated with 333 diagrams, reproductions of engravings and photographs, sprinkled with 2,236 footnotes, this book gives an account of planetariums, tellurians, orreries, globe clocks, astrolabes, lunariums, astronomical clocks, equatoriums, satellitians, cometariums; all of them, to the modern eye mechanical analogue computers of the Solar System, but differing in the way the data are displayed. These models—often of great beauty—are now, as are all analogue computers, being superseded. At the end of the book the most modern planetarium is described, with the heavenly bodies represented by spots of light projected on the interior of a dome vaulting over the audience, and controlled by a digital mini-computer.

Astronomers, who often earned their keep as astrologers, have observed from the earliest times onward the recurrent motions of the heavens, and the bodies moving in them—Sun, Moon and planets. Whether or not awed by "the infinity of those spaces", they determined with ever-increasing accuracy the different periods of these motions, whose ratios are never exactly expressible as finite quotients. Hence the challenge to clever craftsmen to produce close approximations by ingenious gearing.

The material is arranged in a roughly chronological order, starting with the little we know about Hipparchos and Archimedes in connection with astronomical models—the protohistory of the subject. Under-water archaeology brought to light the next item, the astonishing Antikythera mechanism, probably made by a Rhodian craftsman in 87 BC, lost in a shipwreck northwest of Crete in about 80 BC, and salvaged by sponge-fishers in the year 1900. Its 30-odd gears were conserved in lumps of calcareous accretion, which only in recent years became amenable to analysis, by X-rays and gamma-rays, on which D. J. Price in 1974 could base the definitive interpretation. The mechanism computed the synodic month and the lunar year and the positions of Sun and Moon on the basis of Meton's (about 430 BC) approximation, in which 19 solar years correspond with 254 sidereal revolutions of the moon, or 235 lunations. As many later geared models, it made use of differential gearing.

Fourteen centuries passed before anything nearly as elaborate was made. The interim is filled by the Arabs with their geared astrolobes, and the Chinese with the waterwheel clock made by Chang Ssu-hsün exactly a millennium ago. Later, this clock was perfected by Su Sung, and lost as a link in the development of technology when the Chinese capital K'aifêng fell to the Chin Tartars in 1126.

The first mechanical clocks date from the end of the thirteenth century, and the equal hour system gained universal acceptance only a century later. Not surprisingly, the first clocks about which we possess detailed information, those of the fourteenth century of Richard of Wallingford and Giovanni de' Dondi, were astronomical clocks. The positions of the Sun, the Moon and the five planets were displayed on separate dials in the latter clock, which is adequately discussed. Regrettably, the same cannot be said for the discussion of Richard of Wallingford's clock, reconstituted by J. D. North and published in final form in 1976: it is unnecessarily brief and marred by errors of detail. Astronomical clocks have been with us ever since those early examples were made.

Astronomical modelmaking received some powerful impulses from developments in cosmography. In 1543 Copernicus published his *De Revolutionibus*, replacing Ptolemy's geocentric Universe by the much more orderly heliocentric one. In 1609 appeared Kepler's *Astronomia Nova* on the properties of the elliptical planetary orbits, providing a new basis for the "equation of time", that is, the difference between sundial time and mean solar time, indicated in many astronomical clocks. In the course of time the production of these display clocks diverged increasingly from scientific clockmaking, which aimed at greater accuracy, culminating in Harrison's marine chronometer of 1735.

The trail of astronomical clock making brings us back to the late sixteenth century, to the court of the landgrave William IV of Hessen-Cassel, who employed some masters of the craft, Eberhard Baldewein and Jost Bürgi; then to England in the seventeenth and eighteenth centuries, when Tompion, Mudge and Pinchbeck made clocks catering to the tastes of educated gentlemen of the time. Astronomical clocks of heroic complexity were made in Central Europe: for instance, by Aurelius a San Daniele and David a San Cajetano at the royal court monastery at Vienna during the second half of the eighteenth century; above all, perhaps, the 'World Machine' finished by Ph. M. Hahn in 1791. Schwilgué made the astronomical clock in Strasbourg in 1842, more or less in this tradition. His workshop was the germ of the firm of Ungerer, makers of a most elaborate clock for the cathedral of Messina in 1933.

The line to be drawn between astronomical clocks and other astronomical displays is, of course, vanishingly thin. In France a development occurred of clock-driven armillary spheres, of which Antide Janvier finished an outstanding example in 1801. In England, orreries were mainly developed as aids in adult education by instructors such as James Ferguson (1710–76), who, as "Wheelwright of the Heavens" has a chapter devoted to his life and work. This development on the home-front of astronomy gave rise to transparent demonstrational orreries for large audiences, and, therefore, of maximum size—a development which ultimately led to the projection planetarium.

This work germinated a quarter of a century ago as a modest project to compile a list of extant models of the Solar System. In 1970 its scope expanded so as to include astronomical clocks and biographical notes. The result bears traces of this gestation. It is a somewhat uneven, but readable account of the elements of the early history of astronomy, horology and instrument making for the interested amateur, to whom the geometry of the various models is explained especially well. On the other hand, the historian of science will find this book useful too, because it has retained its original character of a catalogue; none other exists. He will recognise some obvious shortcomings—rather heavy reliance on secondary literature, occasional inaccuracies and the absence of a firm terminus to the references. As stated before, the findings of J. D. North—also referred to as J. and J. G. North—on the clock designed and executed by Richard of Wallingford—also referred to as Robert—are rather inaccurately reproduced. The book by Leopold of 1974 on the Reinhold astronomical table clock is not among the references, nor is Maurice's authoritative book on German geared clocks, although an article by the same author in the September issue of the *Connoisseur* of the same year (1976) is included.

These, however, are only minor flaws in this wide-ranging book, which offers much at a reasonable price. □

A. W. Sleeswyk is Professor of Applied Physics at the University of Groningen, The Netherlands.