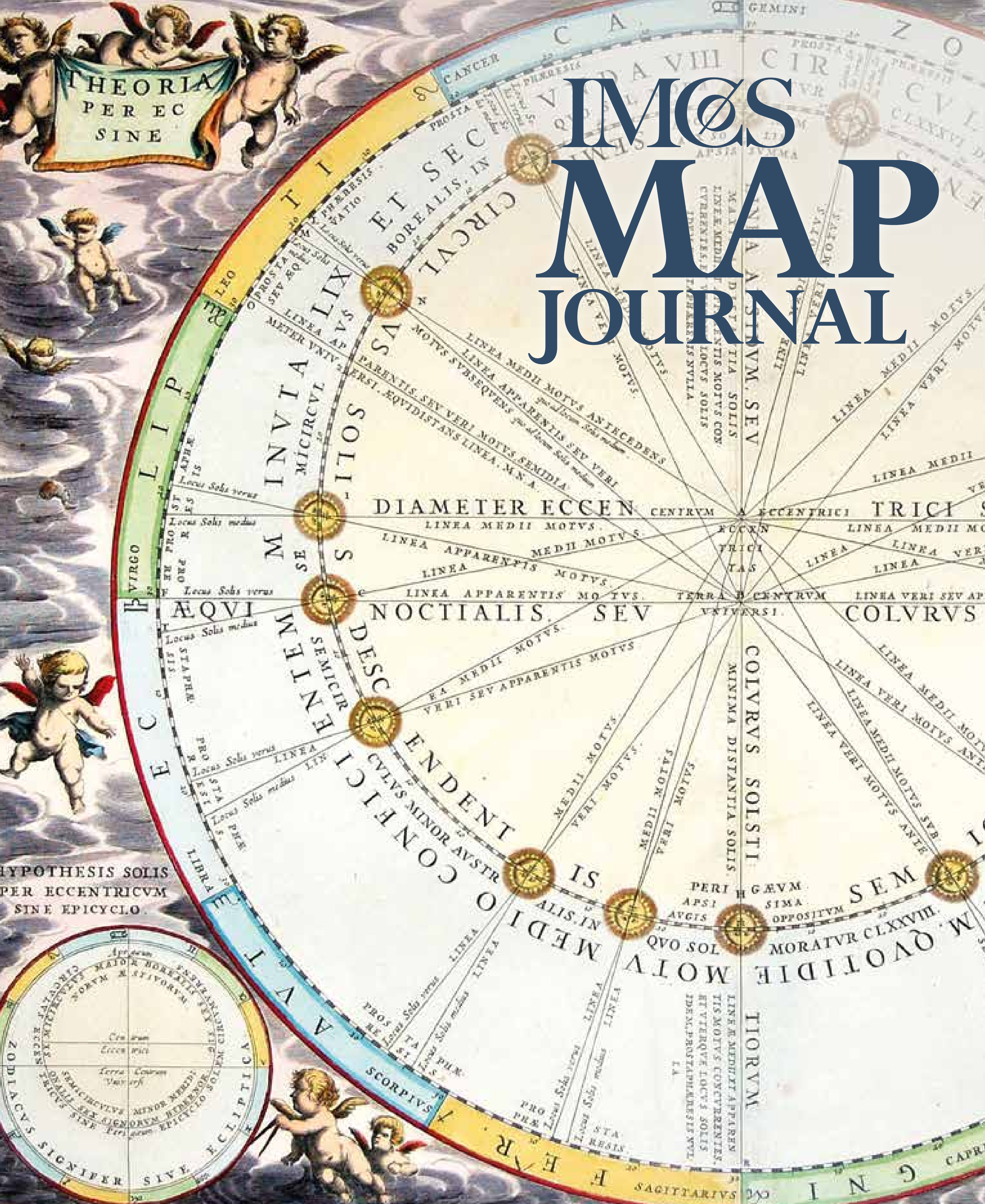
IMCoS MAP JOURNAL



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ARTICLES

REGULAR ITEMS

Front cover Detail of celestial map from Andreas Cellarius' *Harmonia Macrocosmica, c.* 1661. From the Nick and Carolynn Kanas collection.

VOLVELLES

Early analogue computers of the heavens bound in books

Nick Kanas

A marvellous book recently appeared for sale on the website of Daniel Crouch Rare Books Ltd.[1] Headlined 'From the astronomical library of Mary, Queen of Scots', this large-format folio entitled *Astronomique Discours* was written by Scotsman James ('Jacques') Bassantin (*c.* 1500–1568)[2] and published in Lyon in 1557 by Jan de Tournes. The website informs us that it is a first edition and a beautifully illustrated compendium on how to calculate planetary positions. It also has a pedigree: it was bound specifically for Mary, Queen of Scots (1542–1587).[3] Gracing Her Majesty's library, it displays her crowned initial, and all the illustrations are in contemporary hand colour. The text and mathematical tables inform us about the movement and interactions of the heavenly bodies in their celestial spheres and describe practical problems related to understanding their positions at a given time. Among the 175 splendid woodcuts, the folio is graced with fourteen volvelles (thirteen of which are full page); these are complete with thirty-six moving parts (Fig. 1).[1]

Volvelles? Moving parts? What in Heaven's name (pun intended) are these? How did they work? Why am I discussing them in a map collector's journal?

Mapping the heavens

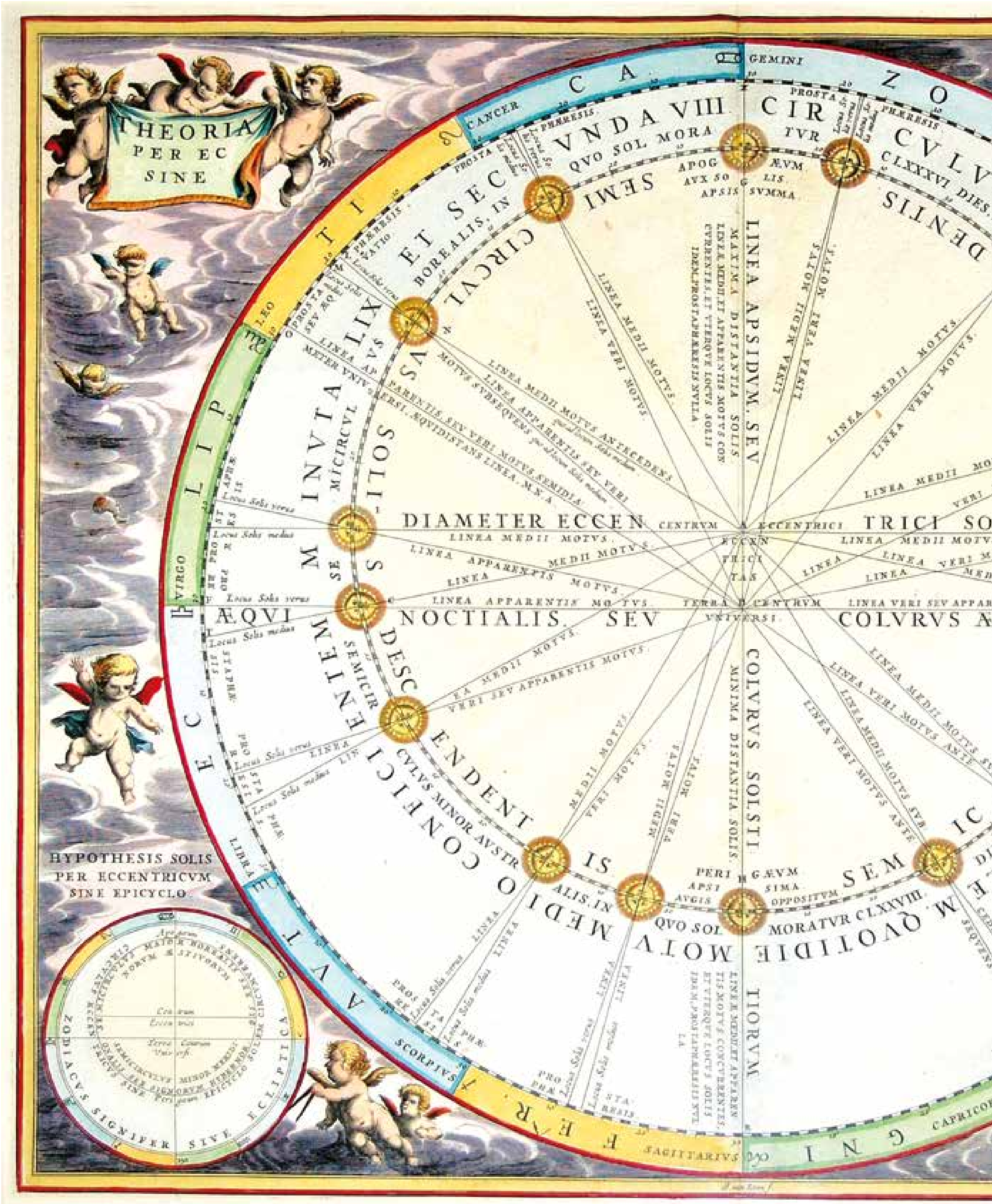
The ability to accurately locate heavenly bodies in the night sky had practical significance for many early cultures in terms of agriculture, navigation, astrology, religion, mythology, and history. For example, the ancient Egyptians heralded the first appearance before sunrise (helical rising) of the star Sirius as a signal that the Nile would soon be flooding the land, making it an optimal time for the planting of crops. For the classical Greeks, accurately locating heavenly bodies in the sky had navigational and astrological significance, and it satisfied their urge to understand the structure of the cosmos. For Islamic peoples, understanding the location of heavenly bodies helped them determine the direction of Mecca, which they needed to face during their prayers. To help organise the heavens, early cultures used fixed stellar patterns called constellations that had important religious and mythological value, and they helped teach history to their young.

Fig. 1 Volvelle from James Bassantin's *Astronomique Discours*, published in 1557. This first edition belonged to Mary, Queen of Scots. Image courtesy of Daniel Crouch Rare Books (crouchrarebooks.com).

But the ancient Greeks went one step further. Using their knowledge of spherical geometry, they placed the stars in an imaginary grid system in the sky oriented to the ecliptic (the path of the Sun). Since the position of each fixed star could be located in terms of degrees of celestial latitude and longitude, a celestial map was created which formed the backdrop for the movement of those heavenly bodies that moved (e.g., Moon, Sun, planets or 'wandering stars').

This system was summarised by the Greek geographer and astronomer Ptolemy (*c.* 100–178 CE) who around 150 CE wrote his famous *Mathematical Syntaxis*, which later received the better known Arab name of *Almagest*. (Ptolemy had two other best-sellers: *Tetrabiblos*, a textbook of astrology, and *Geographia*, the encyclopedia of geographical knowledge whose resultant printed maps are well known to map collectors). The *Almagest* described Greek mathematical astronomy, which viewed the Earth as being in the centre of the cosmos surrounded by the Moon, Sun, and planets (Fig. 2).[4] To mathematically predict the locations of these heavenly bodies in the sky at a particular time, each was portrayed as being affixed on a small circular orbit called an epicycle whose centre revolved around the central Earth along a large circular orbit called a deferent. By adjusting the speed and direction of revolution of these orbits, the actual location in the sky of the celestial object at a given time could be calculated using spherical geometry. For some heavenly bodies, like the Sun, constructing an eccentric orbit served the same purpose, as shown in Figure 2. These models did not need to represent reality; they simply had to mathematically account for observed phenomena, such as the fact that the period of time between the autumnal and vernal equinoxes (178 days) was shorter than the period of time between the vernal and autumnal equinoxes (187 days).[5]

The *Almagest* also included a catalogue of 1,022 stars that were listed not only by their location in one of the


THEORIA PER EC SINE
HYPOTHESIS SOLIS PER ECCENTRICVM SINE EPICYCLO
DIAMETER ECCEN TRICI
ÆQVI NOCTIALIS. SEV COLVRVS
LINEA APSIDVM. SEV
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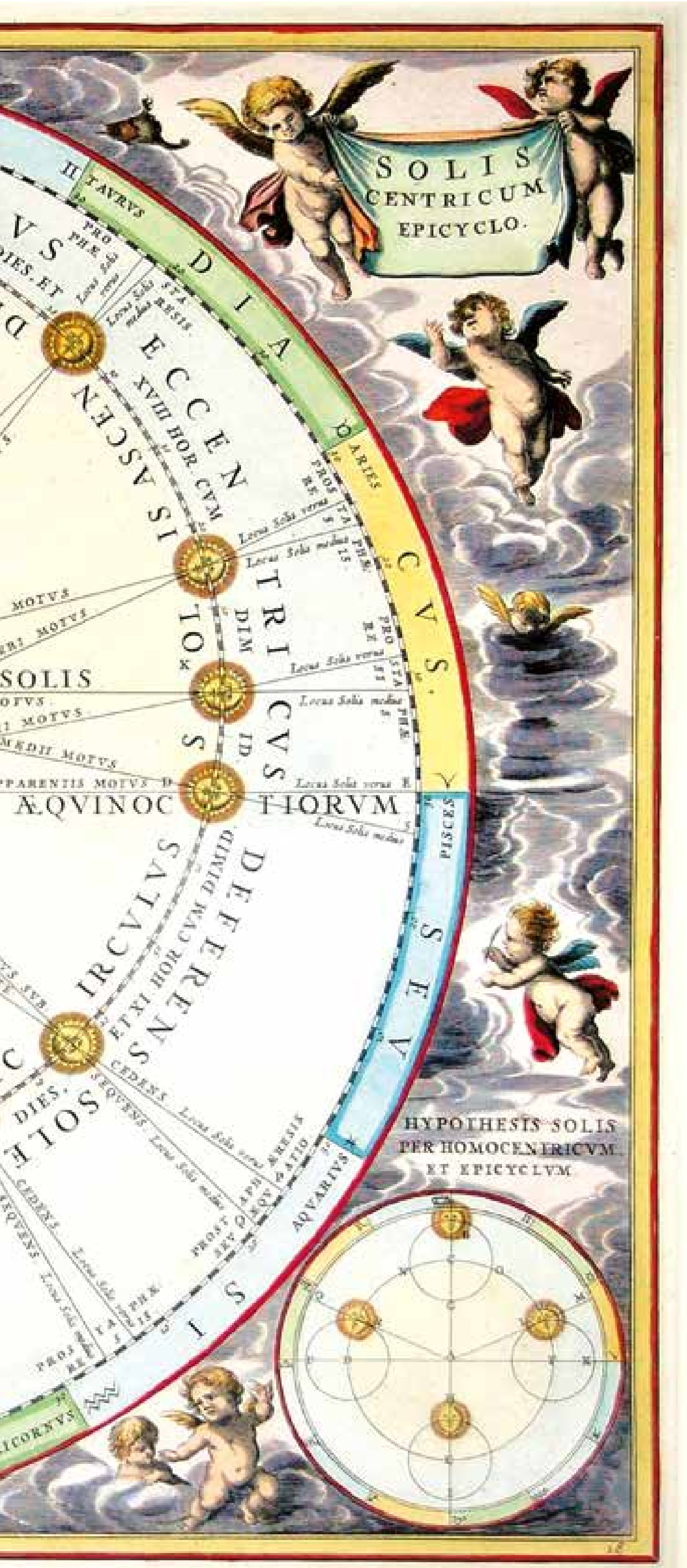

forty-eight classical Greek constellations, but also by their location in the sky in terms of degrees of latitude and longitude. Thus, each star was mapped according to its position in this celestial coordinate system. This grid model was preserved by the Arabs and the Byzantines and was brought back to Europe in the Middle Ages.

To determine the position and movement of heavenly bodies in the sky (as well as to tell time and determine one's latitude on Earth), instruments were developed such as the armillary sphere and the astrolabe.[6] Such instruments were made of wood or metal, were expensive to produce, and were used mainly by astronomers, scholars, and others who could afford the price. But with the advent of movable type in Europe in the 1450s, an opportunity arose to incorporate the principles of these instruments into books, which could be produced more cheaply and reach more people. These movable devices on the printed page were called volvelles.

The arrival of the volvelle

According to the 5th edition of *The Shorter Oxford English Dictionary,*[7] a volvelle was a 'device consisting of one or more moveable circles surrounded by other graduated or figured circles, for calculating the rising and setting of the sun and moon, the state of the tides, etc'. They essentially were early analogue computers that were used for many purposes besides determining the location of a heavenly body (e.g., determining the time of day or night, calculating the number of Sundays until Easter). Specialised volvelles called equatoria were developed to show the relationship between the heavenly bodies and were used for teaching purposes.

Since there is evidence that the ancient Greeks and Arabs used armillary spheres and astrolabes, it is possible that they also developed volvelles, but no extant examples exist. Samples from European manuscripts appear as far back as the thirteenth century. They became popular with the explosion of printed books during the Renaissance. Printed volvelles were

Fig. 2 Andreas Cellarius, *Harmonia Macrocosmica*, *c.* 1661. 42.1 × 50.4 cm; 38.5 cm dia. central diagram. A celestial map based on Ptolemy's model showing the orbit of the Sun around the central Earth with reference to the Zodiac constellations in the ecliptic, which are shown around the periphery. The eccentric orbit accounts for the known unequal period of time between the equinoxes, with the lower part (autumn to spring) being shorter than the upper part (spring to autumn). At the lower right of the page, a model using an epicycle and deferent also produces an eccentric circular orbit, as can be seen by connecting the four Sun images. From the Nick and Carolynn Kanas collection.