6 · Globes in Renaissance Europe

Elly Dekker

Introduction

In 1533 Hans Holbein the Younger, the foremost painter then in London, made the portrait now known as *The Ambassadors* (fig. 6.1).[1] One of the remarkable features of this painting is the abundance of scientific instruments depicted in it. On the top shelf there is a celestial globe, a pillar dial, an equinoctial dial (in two parts), a horary quadrant, a polyhedral dial, and, on top of a book, an astronomical instrument known as a torquetum. On the lower shelf there is a terrestrial globe, a book on arithmetic, a set square and a pair of dividers, a lute with broken strings, a case of flutes, and a hymnbook.[2] The objects displayed between the two men are rarely seen together in paintings. Why they were included in *The Ambassadors* and what message they should convey to the audience are still a matter of debate between art historians. Whatever they mean, for the history of globemaking the appearance of a pair of globes in such worldly surroundings as the London court is very telling.

Holbein's *Ambassadors* is not the first painting showing both a terrestrial and a celestial sphere (plate 4). In the lower right corner of *The School of Athens,* the well-known fresco painted by Raphael in 1510–11, a group of men is engaged in discussion: Euclid with a slate board and a pair of dividers, Ptolemy with a terrestrial sphere in his hand, and a third person, who is said to be the great mystical magician Zoroaster, carrying a celestial sphere.[3] The important thing to note in comparing the globes painted by Raphael with those of Holbein is that those of Raphael do not seem to be real things, whereas those of Holbein certainly are.[4]

A feature that stands out very clearly in *The Ambassadors* is the difference in the way the terrestrial and the celestial globes are mounted. The celestial globe depicted by Holbein has all the accessories of a fully operative globe. It appears that its model was a celestial globe by Johannes Schöner.[5] The terrestrial globe lacks a mounting that would allow one to set the sphere in agreement with one's place on earth.[6] Instead the globe is mounted on a handle, as is observed in some early armillary spheres.[7] Globes mounted in this particular way have not

Abbreviations used in this chapter include: *Globes at Greenwich* for Elly Dekker et al., *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum, Greenwich* (Oxford: Oxford University Press and the National Maritime Museum, 1999).

1. The best study of the painting and its provenance still is the book by Mary Frederica Sophia Hervey, *Holbein's "Ambassadors": The Picture and the Men* (London: Bell and Sons, 1900). See also Susan Foister, Ashok Roy, and Martin Wyld, *Holbein's Ambassadors* (London: National Gallery Publications, 1997), esp. 30–43; the information about the globes and the instruments provided in this catalog should be considered with some care.

2. The book on arithmetic is that by Peter Apian, titled *Eyn newe und wolgegründete underweisunge aller Kauffmans Rechnung* (Ingolstadt, 1527), and the hymn book is by Johann Walther [Walter], *Geystliche gesangk Buchleyn* (Wittenberg, 1525).

3. James H. Beck, *Raphael: The Stanza della Segnatura* (New York: George Braziller, 1993), 88–89; see also José Ruysschaert, "Du globe terrestre attribué à Giulio Romano aux globes et au planisphère oubliés de Nicolaus Germanus," *Bollettino dei Monumenti Musei e Gallerie Pontificie* 6 (1985): 93–104, esp. 102–4.

4. From the perspective of globemaking, this is a pity. Had Raphael looked around for a model for his globes, he could have chosen the pair built in 1477 by Nicolaus Germanus, then available in the Vatican; see Ruysschaert, "Du globe terrestre," 103. Another "concept" globe, a transparent celestial globe showing the earth inside it, was painted by Raphael in one of the corners of his Stanza in the Vatican; see Kristen Lippincott, "Raphael's 'Astronomia': Between Art and Science," in *Making Instruments Count: Essays on Historical Scientific Instruments, Presented to Gerard L'Estrange Turner,* ed. R. G. W. Anderson, J. A. Bennett, and W. F. Ryan (Aldershot: Variorum, 1993), 75–87. It must be said that the celestial map of Raphael's globe is fairly realistic, and the same can be said of the map of the terrestrial sphere in Donato Bramante's fresco of 1490–99 depicting Democritus and Heraclitus. This shows that terrestrial and celestial globes were not uncommon around 1500 anymore. For Bramante's globe, see Jay A. Levenson, ed., *Circa 1492: Art in the Age of Exploration* (Washington, D.C.: National Gallery of Art, 1991), 229.

5. The attribution is justified in Elly Dekker and Kristen Lippincott, "The Scientific Instruments in Holbein's *Ambassadors:* A Re-Examination," *Journal of the Warburg and Courtauld Institutes* 62 (1999): 93–125. See also Elly Dekker, "The Globes in Holbein's Painting *The Ambassadors,*" *Der Globusfreund* 47–48 (1999): 19–52 (in English and German).

6. The maker of the model for the terrestrial globe has not yet been identified. Considering that this globe lacks a scale along the equator, it is doubtful that the model was made by a professional globemaker of similar repute to that of Johannes Schöner.

7. An example of an armillary sphere with handle is shown in *Focus Behaim Globus,* 2 vols. (Nuremberg: Germanisches Nationalmuseums, 1992), 2:518–19 (no. 1.17).

FIG. 6.1. *THE AMBASSADORS,* PAINTED BY HANS HOLBEIN, 1533. Oil on oak. This full-length portrait was designed for the château of the Dinteville family in Polisy, a small village southeast of Paris. To the left one sees Jean de Dinteville, the French ambassador to Henry VIII; on the right is his friend George de Selve.
Size of the original: 207 × 209.5 cm. Photograph © National Gallery, London (NG 1314).

come down to us, but it makes sense to assume that such globes did exist for a short time.

The terrestrial globe in *The Ambassadors* also attracts attention for showing the line dividing the world into two spheres of influence, as agreed in the Treaty of Tordesillas between Spain and Portugal in 1494. In diplomatic circles the division of the world, however indefensible, was a topic of great political importance that resulted in, among other things, one of the most daring undertakings of those days: the first circumnavigation of the world.

The voyages of discovery had a great impact on globemaking, as is well illustrated by the development of the maps of the terrestrial globe. The celestial map was also eventually affected by new data gathered by early explorers. Nevertheless, the explorations alone do not explain the striking rise in popularity of both types of globe around 1500. If the history of cartography in the Renaissance teaches one thing, it is the enormous progress made at that time in understanding the various projections that can be used for mapping the surface of the earth on a plane. How, then, could the globe be so successful in competing with the much cheaper maps of the world? Or, to put it differently, what does a globe offer that a map does not? A first step toward answering this question is to adopt a definition of a globe that differs from the general nineteenth-century perspective, in which a globe was valued predominantly for the map on the surface of its sphere. In this chapter globes are considered as (mechanical) representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world.[8] Only when seen in this way can one hope to understand why "geographers in the early and middle years of the 16th century were concerned how best to express the relationship between the terrestrial and celestial spheres," why "the generally accepted solution was a matching pair of terrestrial and celestial globes accompanied by a book of instruction," and why "these remained for some 300 years the main instruments and method of geographical teaching."[9] Readers interested simply and singly in the mappings of globes are referred to the literature cited in the list of globes in appendix 6.1.

The Legacy

medieval concepts

In discussing the legacy of ancient and medieval science, Lindberg made a point of explaining to his readers that scholars in the past had been "preoccupied with a problem of their own—namely, the need to comprehend the world in which *they* lived, within the bounds of an inherited conceptual framework that defined the important questions and suggested useful ways of answering them."[10] What, then, was the inherited conceptual framework that the scholars of the Renaissance were part of?

The overall scheme to which the discussions about the structure of the world were limited around 1500 is shown in figure 6.2. It is taken from one of the many editions of the most popular textbook in the Renaissance, the *Cosmographicus liber,* first published in 1524 by Peter Apian.[11] With small variations, it is encountered and explained in many textbooks on Renaissance cosmography.[12] One such description, for example, from *The Castle of Knowledge,* written by the English physician Robert

8. This definition is a free adaptation of that used for maps in the preface of *HC* 1:xv–xxi, esp. xvi.

9. Helen M. Wallis and Arthur H. Robinson, eds., *Cartographical Innovations: An International Handbook of Mapping Terms to 1900* (Tring, Eng.: Map Collector Publications in association with the International Cartographic Association, 1987), 26; Elly Dekker, "The Doctrine of the Sphere: A Forgotten Chapter in the History of Globes," *Globe Studies* (English version of *Der Globusfreund*) 49–50 (2002): 25–44.

10. David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450* (Chicago: University of Chicago Press, 1992), 363.

11. Peter Apian, *Cosmographicus liber* (Landshut, 1524).

12. For a good review, see S. K. Heninger, *The Cosmographical Glass: Renaissance Diagrams of the Universe* (San Marino, Calif.: Huntington Library, 1977), esp. 35–38 and 41.

FIG. 6.2. THE PTOLEMAIC UNIVERSE. A schematic presentation of the Ptolemaic universe from Peter Apian, *Cosmographicus liber* (Landshut, 1524). The outermost sphere is the empyrean, habitation of God and all the elect; the tenth sphere is the prime mover; the ninth sphere, the crystalline sphere; the eighth sphere, the firmament; the seventh sphere, Saturn; the sixth sphere, Jupiter; the fifth sphere, Mars; the fourth sphere, the sun; the third sphere, Venus; the second sphere, Mercury; the first sphere, the moon; and finally the sublunary spheres of fire, air, and water-land.
Size of the original: 15.4 × 14.3 cm. Photograph courtesy of the James Ford Bell Library, University of Minnesota, Minneapolis.

Recorde in 1556, reads: "The whole worlde is rounde exactlye as anye ball or globe, and so are all the principall partes of it, everye sphere severallye and joyntlye, as well of the Planetes, as of the Fixed starres, and so are all the foure Elementes. And they are aptely placed togither, not as a numbre of rounde balles in a nette, but every sphere includeth other, as they be in ordre of greatnes, beginning at the eighte sphere or firmamente, and so descending to the laste and lowest sphere, is the Sphere of the Mone: under which the foure elementes succede: first the fier, then the ayer: nexte foloweth the water: which with the earth joyntlie annexed, maketh as it were, one sphere only."[13]

This Renaissance model of the world is in many respects the same as that taught to students as part of the liberal arts in the Middle Ages and described in the popular astronomical textbook the *Sphere,* written by thirteenth-century author Johannes de Sacrobosco (John of Holywood or Halifax).[14] In addition to describing the system of (nine) spheres, his treatise contains a description of the structure of the celestial sphere as it had been codified throughout the centuries by the outline of its main circles, and demonstrated by armillary spheres. Thus in the chapter "Of the Circles and Their Names," a number of greater and smaller celestial circles are explained. Of these various circles there are two that are directly related to the location of a place on earth and later were materialized in globes:

> There are yet two other great circles in the sphere, namely, the meridian and the horizon. The meridian is a circle passing through the poles of the world and through our zenith [that is, the pole of our local horizon], and it is called "meridian" because, wherever a man may be and at whatever time of year, when the sun with the movement of the firmament reaches his meridian, it is noon for him. For like reason it is called the "circle of midday." And it is to be noted that cities of which one is farther east than the other have different meridians. The arc of the equinoctial intercepted between two meridians is called the "longitude" of the city. If two cities have the same meridian, then they are equally distant from east and from west.[15]

Thus the longitude of a place on earth was clearly defined in the Middle Ages, and although Sacrobosco himself does not consider ways to determine the longitude, a method for doing so with the help of a lunar eclipse is mentioned, for instance, in the thirteenth-century commentary of Robertus Anglicus.[16] Sacrobosco is less direct in his definition of latitude. Yet the elevation of the pole above the horizon is discussed, and it is shown that its value equals the distance of the zenith from the equator, which in the commentary of Robertus Anglicus is explicitly recognized as being the latitude of a place.[17] It may therefore be taken for granted that from the later Middle Ages on there existed a clear notion of spherical coordinates such as longitude and latitude, although such coordinates were not yet used in mapmaking but served predominantly astronomical purposes.[18]

One of the characteristics of the *Sphere* of Sacrobosco is its emphasis on the rudiments of astronomy. The planets or wandering stars are hardly mentioned. An exception was made for the sun, and understandably so. Although the sun did not occupy the central position in the Ptolemaic world system, it played a vital role in the outline of the world at large and continued to do so in the Re-

13. Robert Recorde [Record], *The Castle of Knowledge* (London: R. Wolfe, 1556), 9–10, quoted from Heninger, *Cosmographical Glass,* 34.
14. Lynn Thorndike, *The* Sphere *of Sacrobosco and Its Commentators* (Chicago: University of Chicago Press, 1949), 118–26. See also David Woodward, "Medieval *Mappaemundi,*" in *HC* 1:286–370, esp. 306–7 (fig. 18.16).
15. Thorndike, Sphere *of Sacrobosco,* 126.
16. Thorndike, Sphere *of Sacrobosco,* 244–45.
17. Thorndike, Sphere *of Sacrobosco,* 231.
18. Woodward, "Medieval *Mappaemundi,*" 323.

naissance world. From classical times until the discovery of compasses, the rising of the sun was used to define the east point, and its setting the west point on the horizon, and when the sun arrived "under"[19] the meridian of a place at noon, it reached its highest distance above the horizon in the south. Various circles of the Ptolemaic celestial sphere—the ecliptic, the tropics, and the colures—can be understood only in terms of the sun's apparent annual and daily motion. In addition, an understanding of the motion of the sun is essential for understanding such geographical concepts as the zones, the climates, and the parallels; from classical times on the most direct way of finding the latitude of a place was by measuring the length of the shadow cast by the sun at noon. Therefore, the role of the sun can certainly not be ignored in discussing the Ptolemaic world.

According to the simplified astronomical theory discussed by Sacrobosco, the sun and the stars—in fact, all the heavenly bodies except the earth—were endowed with two types of movement. The first, a daily motion, was generated by the outermost sphere of the universe, the so-called *primum mobile,* or the first mover. By it the sun and the stars were pulled round the axis of the world in twenty-four hours, rising in the east and setting in the west.

The other motion was opposite to the daily rotation and around an axis through the poles of the ecliptic. This great circle was called ecliptic because "when sun and moon are on that line there occurs an eclipse of sun or moon."[20] By convention the ecliptic is divided into the twelve signs of the zodiac, such that the signs of Aries and Libra start at the respective points of intersection between the ecliptic and the equator or equinoctial line, the great circle defined by the poles of the world. The annual motion of the sun "beneath" the ecliptic explains the varying length of the day during the seasons, and the small circles, known as the Tropics of Cancer and Capricorn, trace its daily motion in the summer or winter when the sun has reached the sign of Cancer or Capricorn, respectively.

THE CONTRIBUTION OF PTOLEMY

The interest in earthly and heavenly affairs was greatly enhanced during the Renaissance by the humanist movement and the revival of interest in classical authors. Two great classical works on astronomy and geography written by the Alexandrian astronomer and geographer Claudius Ptolemy, his *Almagest* and his *Geography,* were among the sources specifically involved in the making of Renaissance celestial and terrestrial globes. The reason for this, it is often claimed, is that the *Almagest* contains the oldest guide for making a celestial globe, and that the *Geography* preserves the oldest instructions for drawing the outlines of lands and seas on the surface of a sphere.[21]

However, it is important to realize that the *Geography* was certainly not intended as a manual for the construction of terrestrial globes.[22] Rather than promoting the construction of globes, Ptolemy complained of the limited scope offered by a globe in comparison with maps, and turned with zeal to explaining the mathematics involved in mapmaking.[23] He definitely appears to have preferred maps to globes.

Similarly it is important to realize that the *Almagest* was not intended as a manual on the construction of celestial globes. The globe described in the *Almagest* is not a common globe. Neither is the *Almagest* an elementary treatise on astronomy. The treatise is written for "those who have already made some progress in the field."[24] For such readers the common globe held no secrets because it was an essential part of the study of the rudiments of astronomy, for example, as described in such treatises as *Introduction to Phaenomena,* written in the first century B.C. by Geminus.[25] If this is so, why did Ptolemy include a description of a globe? The clue is called precession, or the "motion of the equinoxes," the phenomenon at the base of the slow variation of the coordinates of the fixed stars over the years. In Ptolemy's day precession was a very novel feature, the understanding of which was crucial in discussing the main theme of the *Almagest,* the motions of the sun and the planets. It is for this reason that a description of a relevant demonstration model, the so-called precession globe, is included in the *Almagest.*[26] With its help, the "motion of the equinoxes" can be imitated by a rotation of the polar axis of the universe around that of the ecliptic. The only surviving globe from the Middle Ages, dating from about 1325 (app. 6.1,

19. The meridians were thought to be part of the eighth sphere!

20. Thorndike, Sphere *of Sacrobosco,* 125.

21. G. J. Toomer, trans. and anno., *Ptolemy's Almagest* (1984; Princeton: Princeton University Press, 1998), 404–7 (7.3), and J. L. Berggren and Alexander Jones, *Claudius Ptolemy's* Geography: *An Annotated Translation of the Theoretical Chapters* (Princeton: Princeton University Press, 2000), 83–84 (1.22).

22. This could possibly explain why no terrestrial globes from antiquity or medieval times are known and why the Islamic world seems not to have taken an interest in the terrestrial globe either.

23. Berggren and Jones, *Ptolemy's* Geography, 82–83 (1.20); the relevant passage is quoted in O. A. W. Dilke and eds., "The Culmination of Greek Cartography in Ptolemy," in *HC* 1:177–200, esp. 185.

24. Toomer, *Ptolemy's Almagest,* 6 and 37 (1.1).

25. For Geminus, see O. Neugebauer, *A History of Ancient Mathematical Astronomy,* 3 vols. (Berlin: Springer, 1975), 2:578–89; see also Germaine Aujac and eds., "Greek Cartography in the Early Roman World," in *HC* 1:161–76, esp. 170–71.

26. Toomer, *Ptolemy's Almagest,* 404–7 (8.3). The best comment on Ptolemy's celestial globe is by Neugebauer, *Ancient Mathematical Astronomy,* 2:890–92 and 3:1399 (figs. 79–80); the interpretation of Ptolemy's celestial globe in Dilke, "Culmination of Greek Cartography," 181–82, is not correct, as is noticed by Emilie Savage-Smith, "Celestial Mapping," in *HC* 2.1:12–70, esp. 43 n. 92. See also Elly Dekker, "Precession Globes," in *Musa Musaei: Studies on Scientific Instruments and Collections in Honour of Mara Miniati,* ed. Marco Beretta, Paolo Galluzzi, and Carlo Triarico (Florence: L. S. Olschki, 2003), 219–35.

no. 1), was made by following the description in the *Almagest* to the very letter. This globe was acquired by Nicolaus Cusanus during a visit in September 1444 to Nuremberg, together with two other instruments and sixteen manuscripts for 38 guilders.[27] In this model the celestial sphere is mounted at the ecliptic poles inside an outer sphere consisting in principle of three brass rings, which represent the colures and the equator, respectively. This outer sphere, which can rotate around the axis through the ecliptic poles of the celestial sphere, represents a movable equatorial coordinate grid, because when it is rotated, the colures, the equatorial poles, and the equator shift their positions. In this way one can adapt the positions of the equatorial poles to an arbitrary epoch. The outer sphere is in principle mounted in a meridian ring at its equatorial poles such that it—and the whole system contained in it—can rotate to demonstrate the diurnal motion of the celestial sphere as usual. Only the solstitial colure of the outer sphere of the Cusanus globe has survived, but the holes in the surface of the globe show that it was used for different epochs, one of which suggests the date of ca. 1325. In the mainstream of globemaking Ptolemy's demonstration model received no following. As a rule, Islamic and Western globes were designed for a specific epoch, meaning that the positions of the stars are correct only for one specific date.

Although Ptolemy exerted little direct influence on the construction of globes, the impact of his two works in providing basic data, such as the geographical coordinates of places and the celestial coordinates of the stars to be plotted on the globe, can hardly be overestimated.[28] These data were not without their shortcomings. With the Latin translation of Ptolemy's *Geography* completed ca. 1406, a lengthy process of adaptation and correction of data began, the description of which lies outside the scope of this chapter. In contrast, all star catalogs used by Islamic globemakers, and by Western globemakers before 1600, are directly or indirectly derived from the original Ptolemaic star catalog published in the *Almagest*. This changed only around 1600, when Tycho Brahe produced a new catalog based on new observations.

Early (Recorded) Globes

Notwithstanding its limitations and uncertainties, Ptolemy's *Geography* provided the bulk of the data needed to make a terrestrial globe, and for that reason terrestrial globemaking initially was closely tied to this work. The first terrestrial globe we hear of is mentioned in a copy of a treatise titled "Regionum sive civitatum distantiae," the original version of which goes back to possibly 1430–35. The treatise starts with instructions for making a terrestrial globe, but its main aim is to describe how to make maps of the type called "Munich cosmographies."[29] The coordinates used in these maps can be obtained only with the aid of a real terrestrial globe. We may therefore assume that such a terrestrial globe was in existence in Vienna at the time. Another early terrestrial globe is mentioned in a 1467 inventory of the library of Philip the Good. Among the objects listed is "a round globe in the form of an apple and a black leather case and a paper book with a vellum binding titled: Explanation of the Globe, in French, beginning on the second leaf with the meridians, and on the last, the sea to the East."[30] This little globe had been made around 1440–44 by a man named Hobit, the court astronomer of Philip the Good, as is clear from a receipt dated January 1443 (or 31 March 1444) for an amount of money paid: "To Master Guillaume Hobit, astronomer, the sum of 78 gold *ridres* as much for his expenses as for his three and a half years' work on the globe according to Ptolemy's description."[31]

Compared to the little-known early development of terrestrial globes, the historical situation of celestial globes is decidedly better. Three objects are known from antiquity: the Farnese Atlas and two recently discovered small celestial spheres, one of which served as decoration at the top of a gnomon.[32] Moreover, from A.D. 800 on-

27. Neugebauer, *Ancient Mathematical Astronomy,* 2:578; Johannes Hartmann, "Die astronomischen Instrumente des Kardinals Nikolaus Cusanus," *Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse,* n.s. 10 (1919). The two other instruments are an astrolabe and a torquetum. An example of the latter instrument is shown on the right of the top shelf of *The Ambassadors* (fig. 6.1).

28. Toomer, *Ptolemy's Almagest,* 341–99 (7.5–8.1); Ptolemy, *The Geography,* trans. and ed. Edward Luther Stevenson (1932; reprinted New York: Dover, 1991), 48–159 (2.1–7.6).

29. Dana Bennett Durand, *The Vienna-Klosterneuburg Map Corpus of the Fifteenth Century: A Study in the Transition from Medieval to Modern Science* (Leiden: E. J. Brill, 1952), 164–79. The term "Munich cosmographies" is used by Durand because the maps are based on cosmographic tables found in the third section of the manuscript in Munich, Bayerische Staatsbibliothek (CLM 14583). On the first terrestrial globe, see chapter 10 in this volume, note 30 (pp. 372–73).

30. Quoted in Jacques Paviot, "La mappamonde attribuée à Jan van Eyck par Fàcio: Une pièce à retirer du catalogue de son œuvre," *Revue des Archéologues et Historiens d'Art de Louvain* 24 (1991): 57–62, esp. 58. See also Jacques Paviot, "Ung mapmonde rond, en guise de Pom(m)e: Ein Erdglobus von 1440–44, hergestellt für Philipp den Guten, Herzog von Burgund," *Der Globusfreund* 43–44 (1995): 19–29. The use of the French word *pomme* or the German *Apfel* to indicate a model of the earth, according to Schramm, shows that at the time such models were not yet common and were associated with what resembled them most: the *Reichsapfel.* See Percy Ernst Schramm, *Sphaira, Globus, Reichsapfel: Wanderung und Wandlung eines Herrschaftszeichens von Caesar bis zu Elisabeth II.* (Stuttgart: A. Hiersemann, 1958), 180.

31. Quoted in Paviot, "La mappamonde attribuée à Jan van Eyck par Fàcio," 59.

32. For the Farnese Atlas, see, for example, Vladimiro Valerio, "Historiographic and Numerical Notes on the Atlante Farnese and Its Celestial Sphere," *Der Globusfreund* 35–37 (1987): 97–126 (in English

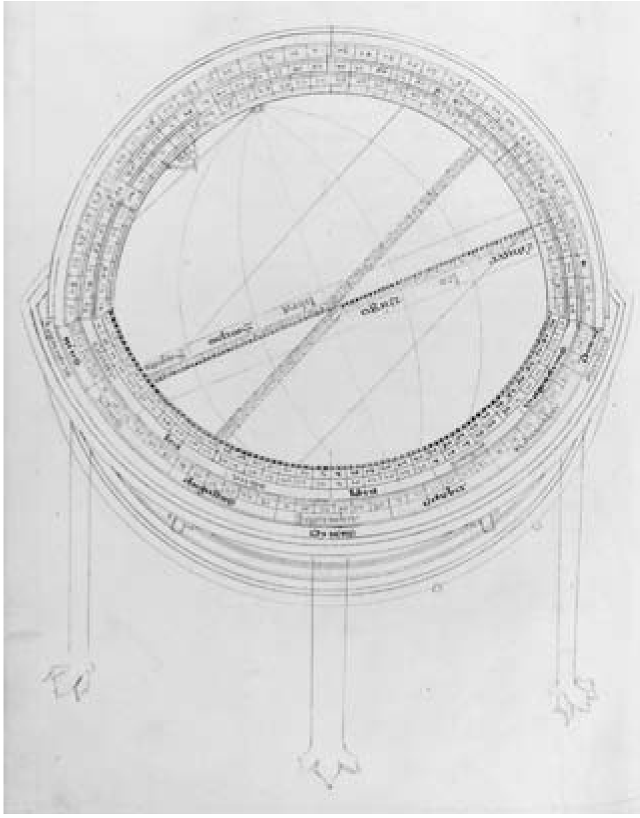

FIG. 6.3. DRAWING OF A CELESTIAL GLOBE. The drawing is from the manuscript treatise "Tractatus de compositione sphaeræ solidæ" dated 1435/44 and connected with the work of Johannes von Gmunden.
Size of the original: 29 × 21 cm. Photograph courtesy of the Bildarchiv, Österreichische Nationalbibliothek, Vienna (Codex 5415, fol. 180v).

ward many globes were produced in the Islamic world.[33] Early medieval treatises on how to make such globes were based on the Islamic traditions. The treatise on the use of the celestial globe by Qustā ibn Lūqā was translated into Latin by Stephanus Arnaldus as *De sphaera solida.* A Spanish version of this work (1259) is included in the collection of studies known as *Libros del saber de astronomía.*[34] And the *Sphaera solida* discussed in a text ascribed to John of Harlebeke in the early fourteenth century is suspected to have been compiled from texts that ultimately derive from Arabic sources.[35]

The earliest records on the production of celestial globes in Western Europe go back to the tenth century.[36] Yet in contrast to its flourishing in antiquity and in the Islamic world, globemaking was not at all successful in the Latin West. The precession globe mentioned earlier is the exception that proves the rule. It appears that in medieval times the European imagination was channeled into making astrolabes rather than globes.[37] This is in fact amazing. Projections of a sphere onto a flat surface usually represent a higher level of abstraction. Understanding them requires knowledge of advanced mathematics. Neugebauer suspects that the excessive attention given to the stereographic projection used in the design of astrolabes effectively delayed the development of spherical trigonometry in Europe.[38] Had there been globes in the Middle Ages, this might not have happened.

An early drawing of a celestial globe from 1435/44 is shown in figure 6.3. It is taken from a manuscript, "Tractatus de compositione sphaeræ solidæ," by the founder of the Viennese astronomical school, Johannes von Gmunden. After his death he left his manuscripts and instruments to the University of Vienna. Among his models was a celestial globe, which may well have had the outer characteristics of the globe drawn in figure 6.3.[39] Other records show that his famous pupils Georg von Peuerbach and Johannes Regiomontanus also owned or were acquainted with the making of celestial globes.[40]

and German); see also Germaine Aujac and eds., "The Foundations of Theoretical Cartography in Archaic and Classical Greece," in *HC* 1:130–47, esp. 142–43. For the other globe, see Ernst Künzl, "Der Globus im Römisch-Germanischen Zentralmuseum Mainz: Der bisher einzige komplette Himmelsglobus aus dem griechisch-römischen Altertum," *Der Globusfreund* 45–46 (1998): 7–153 (in German and English); Ernst Künzl, with contributions from Maiken Fecht and Susanne Greiff, "Ein römischer Himmelsglobus der mittleren Kaiserzeit: Studien zur römischen Astralikonographie," *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 47 (2000): 495–594; Alexis Kugel, *Spheres: The Art of the Celestial Mechanic* (Paris: J. Kugel, 2002); and Hélène Cuvigny, "Une sphère céleste antique en argent ciselé," in *Gedenkschrift Ulrike Horak (P. Horak),* 2 vols., ed. Hermann Harrauer and Rosario Pintaudi (Florence: Gonnelli, 2004), 2:345–81.

33. Emilie Savage-Smith, *Islamicate Celestial Globes: Their History, Construction, and Use* (Washington: Smithsonian Institution Press, 1985), and idem, "Celestial Mapping," 42–49.

34. Savage-Smith, *Islamicate Celestial Globes,* 21–22. See also Richard Lorch, "The *Sphera Solida* and Related Instruments," in *Arabic Mathematical Sciences: Instruments, Texts, Transmission,* by Richard Lorch, item XII (Aldershot: Variorum, 1995), esp. 158.

35. Lorch, "*Sphera Solida.*"

36. A celestial globe is mentioned in a letter of 15 January 989 by Gerbert; see Pope Sylvester II, *The Letters of Gerbert, with His Papal Privileges as Sylvester II,* trans. and intro. Harriet Pratt Lattin (New York: Columbia University Press, 1961), 184–85.

37. We touch here the central question: what can globemaking add to the main stream of historical inquiry in the Middle Ages? Understandably, such inquiry concentrates on what did happen, and therefore, very little work has been done on finding out why no celestial globes were made in the Middle Ages!

38. Neugebauer, *Ancient Mathematical Astronomy,* 2:858.

39. For the instruments, see his will in Paul Uiblein, "Johannes von Gmunden: Seine Tätigkeit an der Wiener Universität," in *Der Weg der Naturwissenschaft von Johannes von Gmunden zu Johannes Kepler,* ed. Günther Hamann and Helmuth Grössing (Vienna: Österreichische Akademie der Wissenschaften, 1988), 11–64, esp. 61.

40. Ernst Zinner, *Regiomontanus: His Life and Work,* trans. Ezra Brown (Amsterdam: North-Holland, 1990), 29, 100, and 164.

The Cosmographer's Globe

principles of cosmography

The making of globes in the Renaissance is closely connected with the principles of cosmography as they were set forth in many sixteenth-century treatises. Some authors, such as the Italian humanist Alessandro Piccolomini, followed in outline the treatise on the sphere of Sacrobosco. Piccolomini's emphasis on the heavenly or astronomical aspects of the universe is expressed, for instance, by the first printed star atlas included in the second part of his book.[41] Other authors, like the professor of Hebrew at Basel University, Sebastian Münster, took Ptolemy's treatise on geography as their model and stressed the earthly or geographical elements. Münster's emphasis on the topography of countries made him the Strabo of the sixteenth century.[42] But to discuss Renaissance cosmography from either an astronomical or a geographical point of view would ignore that the essence of sixteenth-century cosmography lies precisely in the combination of the knowledge of heaven and earth. However, before discussing this, a word must be said concerning the actual making of globes.

Traditionally, globes were made of either brass, silver, or wood, as is exemplified by the surviving globes of, for instance, Hans Dorn and Martin Behaim (fig. 6.4 and app. 6.1, nos. 3 and 4). The materials used for these so-called manuscript globes, notably brass and silver, were very expensive, and the process of engraving or painting a map on the surface of the globe was very time-consuming. This situation completely changed at the turn of the fifteenth century, when the idea of printing segments of paper to be pasted on a sphere was born. Printed globes form part of a much larger group of printed instruments made by pasting prefabricated paper scales on wood. An example of a printed instrument other than a globe is the quadrant shown on the top shelf of *The Ambassadors* (fig. 6.1). Such instruments were included in books, the best example of which is Peter Apian's *Instrument Buch* published in the vernacular in Ingolstadt in 1533. Printed instruments and globes were much cheaper than their brass counterparts.[43] And although special manuscript globes continued to be made for the very rich (see pp. 155–57), the new way of production made it possible to serve a much wider audience.

In the history of globemaking the best and most famous example of early globe printing is connected with a

fig. 6.4. THE OLDEST TERRESTRIAL GLOBE. This oldest surviving terrestrial globe was made in 1492 for the Nuremberg merchant Martin Behaim by Ruprecht Kolberger and painted by Georg Glockendon the Elder. Its cartography is a mixture of Ptolemaic and medieval maps and so-called portolan charts.
Size of the original: diameter 51 cm; height 133 cm. Photograph courtesy of the Germanisches Nationalmuseum, Nuremberg (inv. no. WI 1826).

41. Alessandro Piccolomini, *De la sfera del mondo . . . De le stelle fisse* (Venice, 1548); see also Deborah Jean Warner, *The Sky Explored: Celestial Cartography, 1500–1800* (New York: Alan R. Liss, 1979), 200.

42. Sebastian Münster, *Cosmographei, oder Beschreibung aller Länder* (Basel, 1550; reprinted [Munich: Kolbl], 1992).

43. Prices of maps: from 1569 until 1593 Christoffel Plantijn bought 277 copies of Mercator's world map of 1569 for prices ranging from two guilders to 2 guilders 8 stuivers, and then decreasing to 1 guilder 10 stuivers. Plantijn sold these maps initially for 2 guilders 10 stuivers and later for 3 guilders.

Prices of atlases: in 1599 Plantijn bought copies of Mercator's atlas in three volumes for 19 guilders each. In 1587 he sold Mercator a copy of Lucas Jansz. Waghenaar's *Spieghel der zeevaerdt* (1585) for 4 guilders 10 stuivers. See Léon Voet, "Les relations commerciales entre Gérard Mercator et la maison Plantinienne à Anvers," in *Gerhard Mercator, 1512–1594: Festschrift zum 450. Geburtstag, Duisburger Forschungen* 6 (Duisburg-Ruhrort: Verlag für Wirtschaft und Kultur W. Renckhoff, 1962), 171–232, and idem, "Uitgevers en Drukkers," in *Gerardus Mercator Rupelmundanus,* ed. Marcel Watelet (Antwerp: Mercatorfonds, 1994), 133–49.

Prices of printed globes: in 1517 Lorenz Behaim paid 2½ guilders for a printed celestial globe 28 centimeters in diameter and an accompanying booklet by Johannes Schöner; see Sven Hauschke, "Globen und Wissenschaftliche Instrumente: Die europäischen Höfe als Kunden Nürnberger Mathematiker," in *Quasi Centrum Europae: Europa kauft in Nürnberg, 1400–1800,* by Hermann Maué et al. (Nuremberg: Germanisches Nationalmuseum, 2002), 365–89, esp. 365. It is not stated how the globe was mounted, but since brass was expensive, it is likely that the globe was mounted in a simple wooden meridian ring and a wooden stand. Printed globes 37 centimeters in diameter by Gemma Frisius, mounted in a wooden meridian ring, were offered in 1568 by Plantijn for 12 guilders a pair, that is, 6 guilders each. When the globe was mounted in a brass meridian ring, the price of Gemma's globe increased to 8 guilders 6 stuivers. The records of the Plantijn office show that from 1566 until 1576 Plantijn sold eighteen pairs of globes 42 centimeters in diameter by Mercator. For these globes he asked

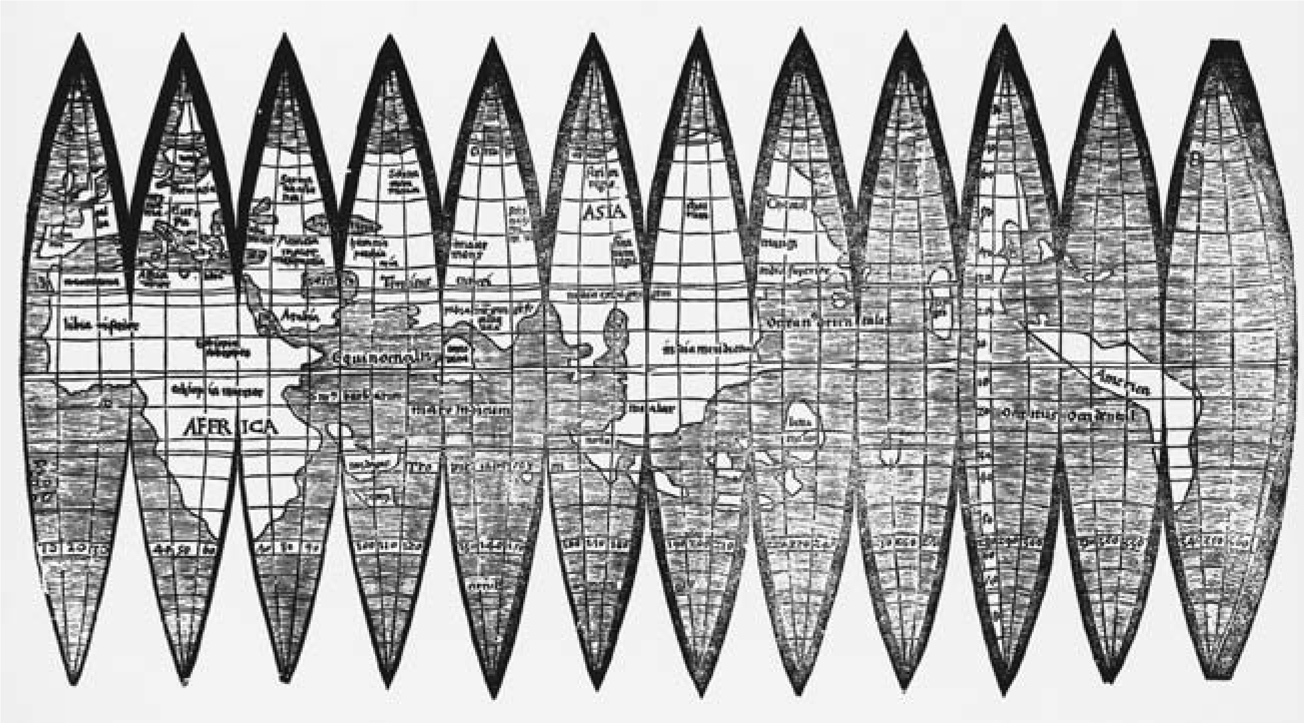

FIG. 6.5. TERRESTRIAL GLOBE GORES. A sheet with the first printed gores (woodcut) for a terrestrial globe, attributed to Martin Waldseemüller, ca. 1507. Size of the original: 24 × 38 cm. Photograph courtesy of the James Ford Bell Library, University of Minnesota, Minneapolis.

small treatise published by Matthias Ringmann and Martin Waldseemüller in 1507: *Cosmographiae introdvctio.*[44] Along with this book, the first printed terrestrial globe gores, now attributed to Waldseemüller, were published (fig. 6.5 and app. 6.1, no. 8). On the back of a fold-out illustration in the book, the authors explain to their readers: "We propose in this booklet to write a sort of introduction to the cosmography which we have illustrated in solid form [a globe] as well as on a flat surface [a map]. It is quite reduced in solid form, of course, because of the limited space, but more detailed on the flat surface."[45] Clearly, in the development of cartography in the early Renaissance, the idea of the sphericity of the earth and the idea of projecting the sphere onto a plane were of equal importance. Another early set of globe gores used as an illustration in a book are those attributed to Louis Boulengier and found in a version of Waldseemüller's *Cosmographiae introdvctio* (app. 6.1, no. 11). According to Wieser, a treatise by Schöner, *Luculentissima quaedā terrae totius descriptio* (Nuremberg, 1515), also closely followed Waldseemüller's book and likewise was accompanied by printed globe gores. Two mounted copies and some fragment gores of Schöner's printed terrestrial globe of ca. 1515 have been preserved.[46] A charter was granted for eight years for Schöner's book with the cosmographic globe—"cum Globis Cosmographicis"—which shows that in this case, too, the mounted globe served as an illustration for the book.[47] Schöner was the first to apply the new technique of using gores to make a printed ce-

prices varying from 12 guilders each in 1566 to 22½ guilders or more after 1576; see Peter van der Krogt, *Globi Neerlandici: The Production of Globes in the Low Countries* (Utrecht: HES, 1993), 72–74.

Prices of manuscript globes: the globe made around 1550 by Jakob Stampfer with a diameter of 14 centimeters was acquired for 124 guilders (see appendix 6.1, no. 55, and fig. 6.8). The production of two globe cups by Jamnitzer received an advance amount of 1,479 gulden; see Ursula Timann, "Goldschmiedearbeiten als diplomatische Geschenke," in *Quasi Centrum Europae,* 216–39, esp. 225. Finally, even more costly were clockwork-driven celestial globes; see *Prag um 1600: Kunst und Kultur am Hofe Kaiser Rudolfs II.,* 2 vols., exhibition catalog (Freren: Luca, 1988), 1:562.

44. Martin Waldseemüller, *Die Cosmographiae Introductio des Martin Waldseemüller (Ilacomilus) in Faksimiledruck,* ed. and intro. Franz Ritter von Wieser (Strassburg: J. H. Ed. Heitz, 1907), and idem, *The Cosmographiae Introductio of Martin Waldseemüller in Facsimile,* ed. Charles George Herbermann (1907; reprinted Freeport, N.Y.: Books for Libraries, 1969).

45. The translation is from Van der Krogt, *Globi Neerlandici,* 28.

46. Appendix 6.1, no. 13, and Franz Ritter von Wieser, *Magalhâes-Strasse und Austral-Continent auf den Globen des Johannes Schöner* (1881; reprinted Amsterdam: Meridian, 1967), esp. 19–28. Fragments of Schöner's terrestrial globe gores of ca. 1515 printed on vellum survive. These fragments were used as binding material in the portfolio containing the Waldseemüller world maps and are now in the Jay Kislak Collection of the Library of Congress. They match the terrestrial globe listed in the appendix as no. 13 but represent a state that differs from the one listed as no. 23 (kind communication by John R. Hébert and John W. Hessler).

47. Van der Krogt, *Globi Neerlandici,* 31.

lestial globe (fig. 6.6 and app. 6.1, no. 12).[48] His activities in Nuremberg show that the design of globe gores was generally known before the method as such was published by Henricus Glareanus in his 1527 treatise on geography.[49]

After a short early period during which printed globe gores were used as illustrations for treatises on cosmography, makers of mounted printed globes started to produce manuals especially written for use in making these globes. Such globe manuals emphasized the mathematical aspects of the astronomical phenomena and the geographical features involved.

Gemma Frisius's Globe Manual

The most interesting early globe manual is *De principiis astronomiae & cosmographiae decque vsu globi* by Gemma Frisius, which was published for the first time in Louvain in 1530.[50] This manual occupies a special place in the history of the development of globe design.

The manual appeared the year after Gemma published a new edition of Peter Apian's *Cosmographicus liber* (1529) at the request of an Antwerp publisher, Roeland Bollaert.[51] Earlier, in 1527, Bollaert had published an edition of Schöner's manuel on the use of the celestial globe. And because Schöner could not meet the demands for his own printed globes, Gaspard van der Heyden, a goldsmith of Louvain, was invited in 1526/27 by Bollaert to produce a new printed celestial globe, the first in a series published in Louvain. As was shown by Van der Krogt, this now lost celestial globe was presumably published together with a terrestrial globe by Franciscus Monachus (François de Malines).[52] This explains why Bollaert did not publish a new edition of Schöner's book, the *Luculentissima,* with the terrestrial globe. The descriptive geography in the latter treatise does not conform to the map on Monachus's globe. Therefore Monachus wrote his own description in a letter to accompany his now lost terrestrial globe.[53]

In contrast to the terrestrial globe mounted on a simple handle, as is depicted in *The Ambassadors,* early terrestrial globes were mounted in the same way as the Behaim globe—in a meridian ring that was supported, in turn, by a stand with a horizon ring. The same construction is seen in the terrestrial globe pictured on the title page of Schöner's *Luculentissima* and on the title page of Apian's *Cosmographicus liber.*[54] Thus around 1530 there were two treatises available in Louvain with clear ideas on the construction of globes, both of which were printed by Bollaert in Antwerp: one on the celestial globe by Schöner and the other on the terrestrial globe by Apian, following Schöner. Schöner's manual on the celestial globe was especially influential in shaping the ideas of Gemma Frisius in globemaking, as the latter fully acknowledged in his globe manual of 1530. Gemma believed, however, that his own treatise had more to offer to his readers, a notion that he repeated again when he explained the use of his globe. But to make sure that no one doubted the true meaning of his debt to and respect for Schöner, he assured his readers: "This is not to be put to the ignorance of the author or to my arrogance; for often it happens that one cannot do everything, and it is easier to add some-

48. Aspects of the first printed globe by Johannes Schöner are discussed in Dekker and Lippincott, "Scientific Instruments," and Dekker "Globes in Holbein's Painting." One set of Schöner's surviving celestial globe gores of ca. 1515 is printed on paper and lacks the main celestial circles (fig. 6.6). Of the other set of gores only fragments printed on vellum survive. Both sets are part of the portfolio containing the Waldseemüller world maps and are now in the Jay Kislak Collection of the Library of Congress. The fragments were used as binding material. These two sets represent different states and both differ from the celestial globe listed in the appendix as no. 24 (see Elizabeth M. Harris, "The Waldseemüller World Map: A Typographic Appraisal," *Imago Mundi* 37 [1985]: 30–53, esp. 38, and Dekker, "Globes in Holbein's Painting," 22–23).

49. Henricus Glareanus, *D. Henrici Glareani poetæ lavreati De geographia liber vnvs* (Basel, 1527), chap. 19; see Van der Krogt, *Globi Neerlandici,* 26, esp. fig. 1.3.

50. Gemma Frisius, *De principiis astronomiae & cosmographiae deq[ue] vsu globi ab eodem editi: Item de orbis diuisione, & insulis, rebusq[ue] nuper inuentis* (Louvain, 1530); see also Fernand van Ortroy, *Bio-Bibliographie de Gemma Frisius* (1920; reprinted Amsterdam: Meridian, 1966), 189–91. I have used a facsimile edition: Gemma Frisius, *De principiis astronomiae & cosmographiae (1553),* intro. C. A. Davids (Delmar, N.Y.: Scholars' Facsimiles and Reprints, 1992). The details of this edition are described by Van Ortroy, *Bio-Bibliographie,* 198–201; see also Van der Krogt, *Globi Neerlandici,* 75–77.

51. More than forty editions of this work by Apian were published in the sixteenth century, and most were edited and enlarged by Gemma. See Fernand van Ortroy, *Bibliographie de l'oeuvre de Pierre Apian* (1902; reprinted Amsterdam: Meridian, 1963). As is noted by Schöner, Apian himself never published another edition of this early work after 1524; only in 1562 was a new edition considered by his son Philipp; see Christoph Schöner, *Mathematik und Astronomie an der Universität Ingolstadt im 15. und 16. Jahrhundert* (Berlin: Duncker und Humblot, 1994), 405.

52. Van der Krogt, *Globi Neerlandici,* 41–48, esp. 44.

53. Franciscus Monachus, *De orbis sitv ac descriptione . . .* (Antwerp, 1526/27). The text is reproduced in Lucien Gallois, *De Orontio Finæo gallico geographo* (Paris: E. Leroux, 1890), 87–105 (app. III).

54. A picture of the terrestrial globe on Schöner's title page is shown in *Focus Behaim Globus,* 2:672. A picture of the terrestrial globe on Apian's title page is shown in Hermine Röttel and Wolfgang Kaunzner, "Die Druckwerke Peter Apians," in *Peter Apian: Astronomie, Kosmographie und Mathematik am Beginn der Neuzeit,* ed. Karl Röttel (Buxheim: Polygon, 1995), 255–76, esp. 262. According to Murschel and Andrewes, there are at least three different states of the first edition. The first state can be recognized by the complete pillar sundial in the picture with the globe. In the two later states only the base of this dial is seen; see Andrea Murschel, trans. and rev., "Translations of the Earliest Documents Describing the Principal Methods Used to Find the Longitude at Sea," intro. William J. H. Andrewes, in *The Quest for Longitude: The Proceedings of the Longitude Symposium, Harvard University, Cambridge, Massachusetts, November 4–6, 1993,* ed. William J. H. Andrewes (Cambridge: Collection of Historical Scientific Instruments, Harvard University, 1996), 375–92, esp. 379 and n. 18.

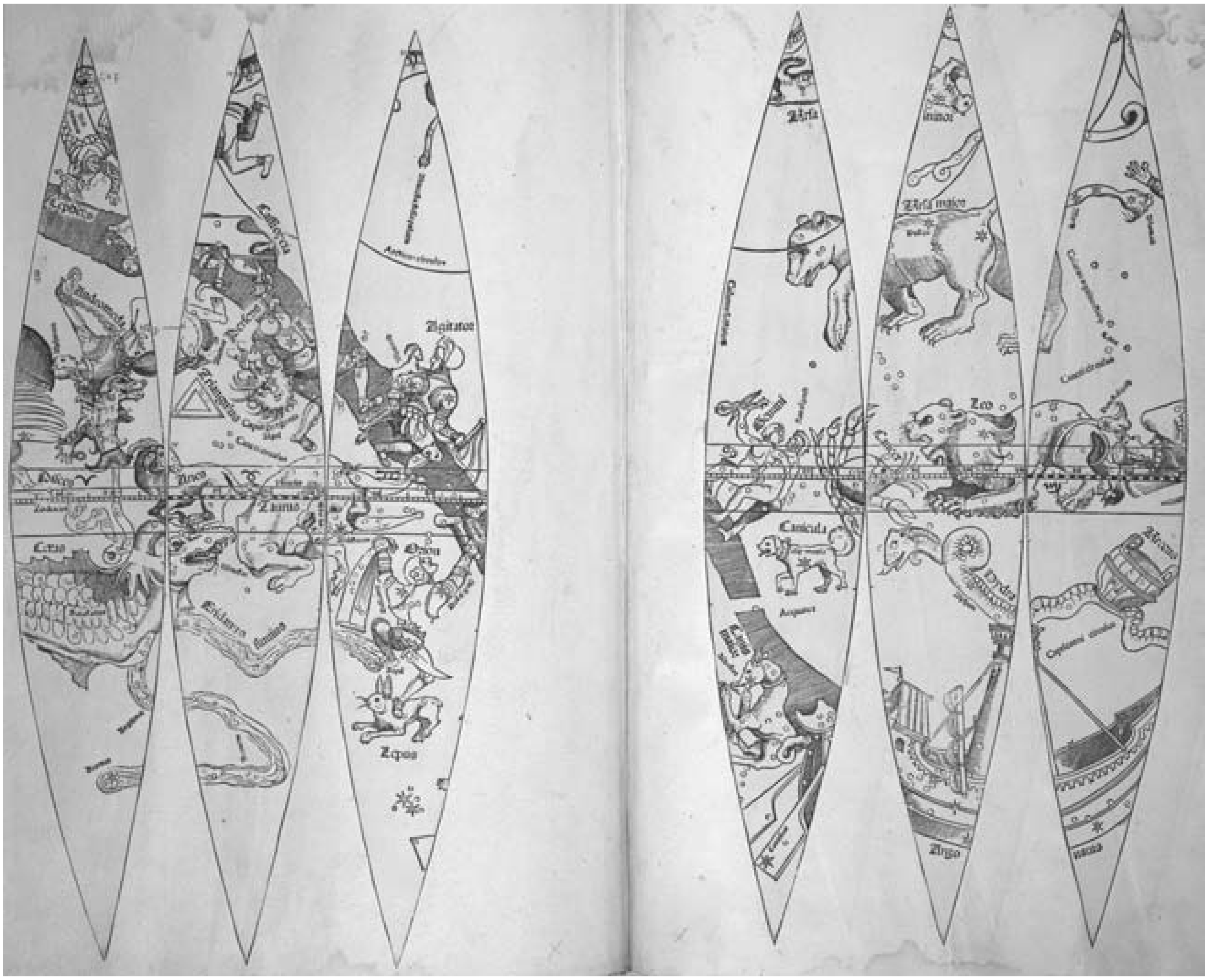

FIG. 6.6. CELESTIAL GLOBE GORES. The first printed gores (woodcut) for a celestial globe, attributed to Johannes Schöner, ca. 1515. The gores are part of the portfolio containing the Waldseemüller world maps, which once belonged to Schöner himself.
Diameter of the mounted globe: 28 cm. Photograph courtesy of the Kislak Collection at the Library of Congress, Washington, D.C.

thing to things already known than to find and discover the muses."[55]

"Adding" to the ideas of others is characteristic of the scientific oeuvre of Gemma. But in doing so, important ideas occurred to him, too. The best-known "addition" in his globe manual is the method for finding the longitude by means of clocks. In globemaking his habit of adding things was crucial for the design of globes during the following four centuries. Although no example has survived, the overall design of his cosmographic globe can be grasped from his manual:

> Such a globe, or spherical body, we have recently very carefully designed; and made it to contain not only the main circles, drawn on its curved surface, such as the equator, the tropics, and the parallels, and other circles of the common sphere, but in between them we have also drawn the regions, islands, mountains and rivers, with their names, with the utmost diligence and care as was possible. And moreover, to clarify the use of the globe, we have distributed over the surface several bright stars, not all of them, but only the most notable ones that are of the greatest importance to astronomers and cosmographers.[56]

Clearly, the cosmographic globe combined three elements: first, the main circles of the armillary sphere as

55. Gemma, *De principiis astronomae & cosmographiae (1553),* 29–30. The translations are from Van der Krogt, *Globi Neerlandici,* 76–77 (based on a French edition).

56. This description is a free rendering of the text in Gemma, *De principiis astronomiae & cosmographiae (1553),* 25–26.

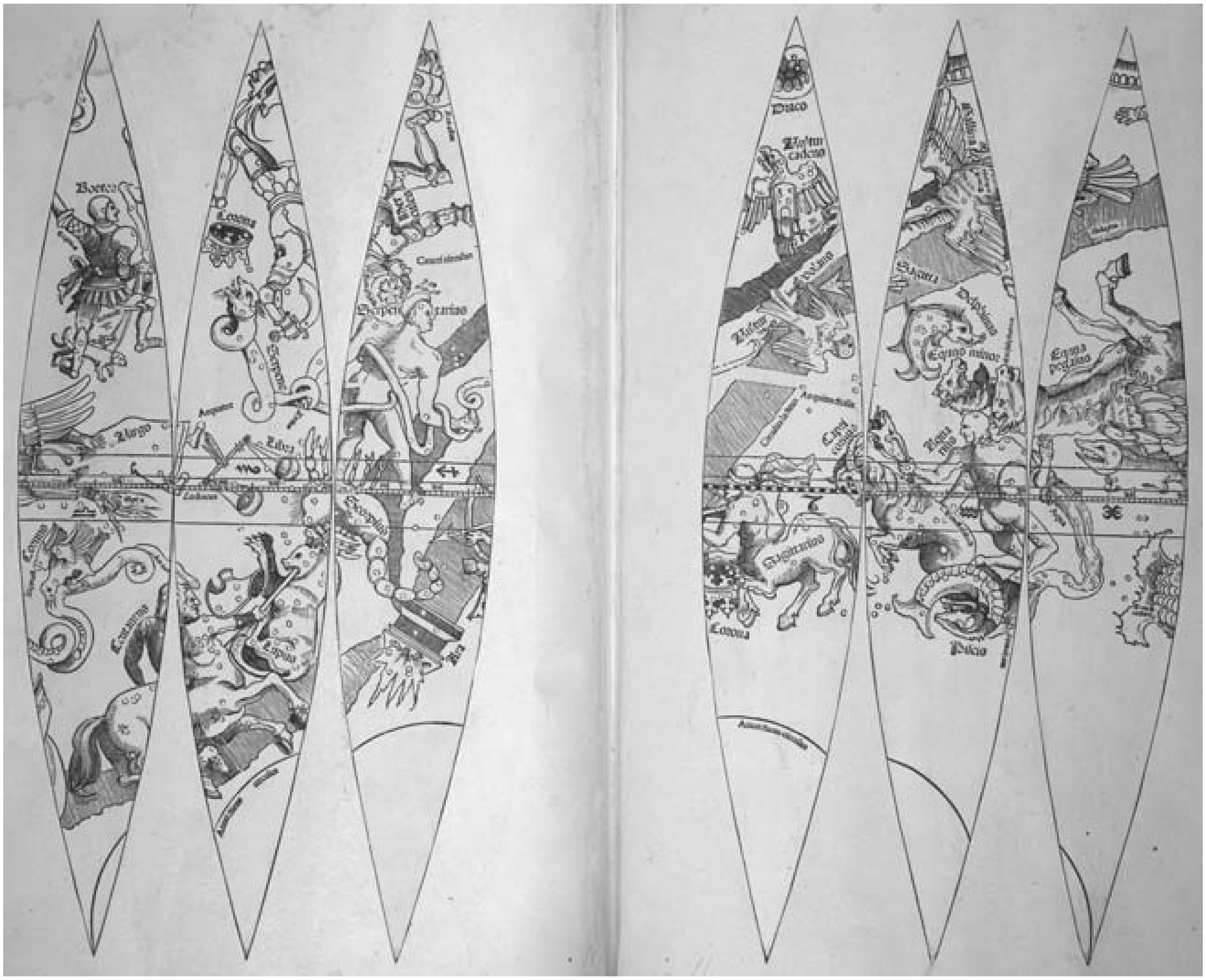

FIG. 6.6. (*continued*)

these were known from Sacrobosco's treatise; second, the outlines of the lands and seas of the terrestrial globe proper; and third, the sphere of the fixed stars, which is expressed through the addition of a number of stars on the globe in between the lands and seas (see fig. 6.7). However, this is not yet complete, because in order to make the most of the globe a number of accessories had to be added, such as a meridian ring, an hour circle with a pointer, a horizon ring, a quadrant of altitude, a semicircle of position, and a so-called spherical gnomon. Most of these accessories were part of the celestial globes made, for example, by Schöner, from 1517 on, as we can see in *The Ambassadors* (fig. 6.1), where there is a meridian ring with an hour circle on top, a stand with a horizon ring, a quadrant of altitude, and a circle of position. The purposes of such accessories was to solve a series of astronomical problems, such as finding the times of the rising and setting of the sun throughout the year and fixing the limits of the twelve houses of the heavens.

What is really new in Gemma's approach is that he added to a terrestrial globe a number of elements properly belonging to a celestial globe, such as the hour circle and a selection of stars. In this process he created a completely new instrument that combined in one model the very inner part (the terraqueous globe) and the outer parts (the eighth sphere of the stars and the sphere of the first mover) of the Ptolemaic universe as it is depicted in so many textbooks (see fig. 6.2). In addition, the phenomena caused by the sun's diurnal and annual motion could be demonstrated with the help of Gemma's spherical gnomon. This made his globe eminently suitable for explaining geography as it was understood by Ptolemy:

> [In world cartography] the first thing that one has to investigate is the earth's shape, size, and position with

FIG. 6.7. DEPICTION OF A COSMOGRAPHIC GLOBE. This picture of the cosmographic globe by Gemma Frisius is from the title page of his *De principiis astronomiae & cosmographiae* (Louvain, 1530). The picture shows the terrestrial sphere adorned with stars and a number of accessories, among which the hour circle on top of the meridian ring is the most notable. Size of the original: 20.5 × 15 cm. Photograph courtesy of the Universiteitsbibliotheek Amsterdam (Ned. Inc 347 2).

> respect to its surroundings [i.e., the heavens], so that it will be possible to speak of its known part, how large it is and what it is like, and moreover [so that it will be possible to specify] under which parallels of the celestial sphere each of the localities in this [known part] lies. From this last, one can also determine the lengths of nights and days, which stars reach the zenith or are always borne above or below the horizon, and all the things that we associate with the subject of habitations.[57]

One might well argue that the design of the mounting of the terrestrial globe by Behaim is not very different from the mounting proposed by Gemma (compare figs. 6.4 and 6.7). However, the terrestrial globe of Behaim does not possess an hour circle. The idea behind a mounting like that of the Behaim globe is to be able to set the globe up to correspond with the situation of a specific city in the world. This process of "rectification" forms the main content of the short chapter on globes included by Apian in his *Cosmographicus liber.*[58] It explains the instruments shown with the terrestrial globe on the title page.

To rectify a globe, one has to ascertain four things. First, that the globe is in a horizontal position (by using a plumb line). Second, that the horizon corresponds to the four parts of the world, so that the meridian ring is aligned with the north-south line. Apian describes three methods for finding the meridian line. Third, that the pole is elevated as many degrees above the horizon as corresponds with the latitude of the location of the user of the globe. And fourth, that the user's location is below the fixed brass meridian ring so that its zenith will agree with the zenith of the fixed horizon of the globe.

The basic parts of the mounting of Behaim's terrestrial globe, such as the mobile meridian ring and the fixed horizon ring, may well have been part of the design of the pair of globes made in 1477 in Rome by the most prolific producer of manuscripts of Ptolemy's *Geography,* Nicolaus Germanus.[59] According to a 1481 inventory of the Vatican library, there was once an "Octava sphera" (a celestial globe) and a "Cosmographia" (a terrestrial globe) exhibited in the *Pontificia* (library).[60] It is important for our discussion that both globes are mentioned again in an inventory of 1487: "A sphere with a horizon ring with land and sea according to Ptolemy. / A sphere showing the heavens with its poles and obliquity."[61] This shows that the globes of Nicolaus Germanus were mounted in a stand with a horizon ring, possibly in the same way as is seen in Behaim's surviving globe of 1492.

Until now most attention has been devoted to the map laid out on the surface of the Behaim globe. The present horizon ring was added to the globe in 1510, and its inscription tells us how this ring is to be understood: "The ring is called the horizon and shows the rising and the setting of the sun and the 12 signs."[62] Here, as before, the mo-

57. Berggren and Jones, *Ptolemy's* Geography, 58 (1.1).

58. I used the Dutch edition of Apian's *Cosmographicus liber, De Cosmographie vã Pe. Apianus,* ed. Gemma Frisius (Antwerp, 1537), xxi verso–xxij recto.

59. The globes are referred to in bills dated 1477, the Latin text of which are in Ruysschaert, "Du globe terrestre," 95–97; for English translations, see Józef Babicz, "The Celestial and Terrestrial Globes of the Vatican Library, Dating from 1477, and Their Maker Nicolaus Germanus (ca 1420–ca 1490)," *Der Globusfreund* 35–37 (1987–89): 155–68, esp. 161–62.

60. Ruysschaert, "Du globe terrestre," 97.

61. Ruysschaert, "Du globe terrestre," 98 (my italics).

62. Roland Schewe, "Das Gestell des Behaim-Globus," in *Focus Behaim Globus,* 2 vols. (Nuremberg: Germanisches Nationalmuseums, 1992), 1:279–88, esp. 283.

tion of the sun is an important clue to understanding a globe. For finding the place of the sun in the zodiac during the year, the horizon rings of celestial globes were provided with a scale of the zodiac alongside a calendar, which was already seen in the drawing of a stand shown in "Tractatus de compositione sphaeræ solidæ" (1435/44) (fig. 6.3). This feature of the celestial globe was also adopted by Gemma for the design of his cosmographic globe.[63]

With the place of the sun in the zodiac known for a specific day of the year, a whole range of cosmographic problems could be demonstrated and solved. But for this purpose an hour circle with an index had to be added on top of the meridian ring—as Gemma did on his cosmographic globe—and one more step in rectifying the globe had to be carried out: the index had to be set to local time, as measured through the diurnal motion of the sun. This was done by bringing the place of the sun in the ecliptic, drawn on the surface of the sphere, under the brass meridian ring in the south and setting the index of the hour circle at twelve o'clock. Once set, all the phenomena having to do in one way or another with the sun's daily motion could be explained. The addition of the hour circle to terrestrial globes must have appealed to globemakers, because from 1530 until late in the nineteenth century most terrestrial globes were provided with this bit of time-related equipment.

Considering the mixture of concepts underlying the cosmographic globe designed by Gemma, a manual explaining its uses was not superfluous. The first part of this globe manual, titled "De principiis cosmographiæ," treats the principles of cosmography: the circles of the sphere, the zones, the climates, the parallels, the longitude and latitude of a place, the names of the various parts of the world (Amphiscii, Heteroscii, Periscii, Antipodes), the winds, and some general notions.

The usefulness of the globe in demonstrating the main circles of the celestial sphere is not difficult to see, but its importance for finding one's place on earth is something that was initially accepted only by astronomers. The concepts underlying great circles such as the equinoctial line (or equator) and the meridian line, and the methods for measuring geographical coordinates such as latitude and longitude, were astronomical. To be able to find a place on earth in this mathematical way, one had to be acquainted with the motion of the sun, moon, or stars. Seen from this perspective, it is not difficult to understand why globe manuals are filled with astronomical problems and why instruments are so often encountered in the early treatises on cosmography. And although the determination of the longitude of a place by the observation of an eclipse in two places was something that remained beyond the practical possibilities of most enthusiasts, the globe served to a great extent to overcome the conceptual difficulties involved.

In the second part of his globe manual, "De vsv globi," Gemma discusses the known methods for finding one's place on earth. And, as usual, he adds a few new ones—for instance, his famous method of finding the longitude with the help of a timepiece.[64] This part of the book unmistakably supports the opinion, advocated by Ptolemy in his *Geography,* that geographical data derived by using mathematical and astronomical methods are to be preferred to those provided by the accounts of travelers.[65] The voyages of discovery at the close of the fifteenth century made this awareness even stronger. As Gemma explains: "The longitudes of many regions, especially of those which the Spanish have discovered, are uncertain or completely unknown to us. For nothing certain can be determined from the winding paths of these voyages, as confirmed by Ptolemy in the first book of his *Cosmographia.*"[66]

The third and last part of the globe manual of Gemma, "De orbis diuisione," is a descriptive geography, the discussion of which is outside the scope of this chapter. It may well be that this was the most interesting part for many of his readers.

THE PRODUCTION OF COSMOGRAPHIC GLOBES

The cosmographic approach to globemaking initiated by Gemma Frisius was followed in particular by Gerardus Mercator, who also added a selection of stars to the terrestrial sphere (see fig. 6.10). His globe should therefore be labeled a cosmographic globe. Other examples of cosmographic globes are the *Poculum cosmographicum* made around 1550 by the goldsmith Jakob Stampfer of Zurich, in which the design of Gemma is applied to a cup in the shape of a globe (fig. 6.8), and the so-called St. Gallen globe (plate 5), which follows Gemma's design in all its details.[67]

The selection of stars engraved on the surface of the cosmographic globe did not really suffice for astrological applications. Gemma, and after him Mercator, designed a separate celestial globe for this purpose (app. 6.1, nos. 34 and 35). This production of a celestial globe alongside a cosmographic one made the use of stars on the latter apparently superfluous in the eyes of globemakers working

63. Gemma, *De principiis astronomiae & cosmographiae (1553),* 27.

64. Gemma, *De principiis astronomiae & cosmographiae (1553),* 64–65.

65. Berggren and Jones, *Ptolemy's* Geography, 28 (1.4).

66. Gemma, *De principiis astronomiae & cosmographiae (1553),* 64; translation from Murschel and Andrewes, "Translations of the Earliest Documents," 390.

67. For Stampfer, see appendix 6.1, no. 55, and for the St. Gallen globe, see Franz Grenacher, "Der sog. St.-Galler Globus im Schweiz. Landesmuseum," *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte* 21 (1961): 66–78.

FIG. 6.8. A CUP OF GILT SILVER IN THE SHAPE OF A COSMOGRAPHIC GLOBE. The cup was made around 1550 by Jakob Stampfer, a goldsmith from Zurich, for the burgomaster of Constance, Thomas Blarer. From him it was acquired in 1555 by Bonifacius Amerbach, who in turn bequeathed it to his friend Theodor Zwinger in 1564.
Size of the original: diameter 14 cm; height 38 cm. Photograph by Maurice Babey, courtesy of the Historisches Museum, Basel (inv. nr. 1882.103).

later in the sixteenth century, because most makers omitted the stars from the terrestrial sphere. What was retained, however, was the superimposed celestial sphere and the hour circle. These parts had proved their value in explaining, for instance, the climates and parallels in terms of the length of daylight on the longest day of the year, and were maintained in the design of the terrestrial globe for these reasons until far into the nineteenth century.

So it came about that from the Renaissance onward the dominant construction in globemaking consisted of a pair of globes, each of which had a mobile sphere mounted in a stand with a number of accessories, notably a movable meridian ring, a fixed horizon ring, and an hour circle. The motions to be demonstrated by this common pair of globes were dictated by the Ptolemaic world system of the first mover and the annual motion of the sun around the earth. In the common pair of terrestrial and celestial globes the diurnal motion of the first mover is reflected by the mobility of both spheres around the axis of the world. For that reason the spheres are always turned from east to west, in tune with the Ptolemaic world picture. When the sphere of a terrestrial globe is turned around, it is either to bring the local horizon of a place in accord with that of the globe or to simulate the daily motion of the sun. When the sphere of a celestial globe is turned around, it is to simulate the daily motion of the stars. The annual motion of the sun around the earth is presented by two design features. The ecliptic is presented on the terrestrial sphere (as part of the superimposed celestial sphere) and on the celestial sphere (as part of the eighth sphere, to which it properly belongs). And the position of the sun in the zodiac throughout the year is displayed graphically on the horizon rings of both globes. This makes it clear what a globe offers that a map does not.

The Use of Globes

"The utility, the enjoyment and the pleasure of the mounted globe, which is composed with such skill, are hard to believe if one has not tasted the sweetness of the experience. For, certainly this is the only one of all instruments whose frequent usage delights astronomers, leads geographers, confirms historians, enriches and improves legists, is admired by grammarians, guides pilots, in short, aside from its beauty, its form is indescribably useful and necessary for everyone."[68] If we are to believe this claim expressed by Gemma Frisius in his globe manual, there existed in the sixteenth century hardly any profession that would not benefit from the globe. He may well have been right. Often globes and armillary spheres are shown in the portraits of scholars and navigators. These associations quickly turned the globe into a symbol of learning and seafaring. And in the paintings of many an emperor or queen, a globe is presented as the

68. Gemma, *De principiis astronomiae & cosmographiae (1553),* 28; translation from Van der Krogt, *Globi Neerlandici,* 77.

symbol of their worldly powers.[69] From these observations, at least three potential groups of users can be distinguished: first, there were intellectuals engaged in teaching and publishing books on science; second, there were so-called practitioners who had an interest in the use of globes that was triggered by their profession—navigators, astrologers, and physicians, etc.; and third, there were the mighty and the rich—emperors, princes, dukes, and popes, with their servants the diplomats and bishops, and the well-to-do patricians and merchants. In the rest of this chapter I consider a few particulars of these various users and conclude with a short discussion of the use of the globe as a symbol.

EDUCATION

The uses of demonstration models in university education is a phenomenon that cannot be viewed separately from the trend to hire specialists for teaching mathematics, astronomy, and geography at universities. In medieval times every master had to be able to teach every part of the curriculum. At the beginning of the semester, the lectures were divided by lot. Thus teaching the liberal arts could be and was done by any master who happened to be around. All these masters often did in teaching was to read certain textbooks to their students. As Schöner pointed out, such a system did not encourage a trend toward specialization among teachers.[70] In the course of the fifteenth century, this situation changed. An early example of a professional teacher was Johannes von Gmunden, whom we have mentioned before. From 1414 until 1434 he lectured in astronomy and mathematics at the University of Vienna, and for his lectures he used a variety of models, among which were an armillary sphere and a celestial globe. Toward the end of the fifteenth century, the impact of humanism helped to establish special chairs for teaching mathematics (which included astronomy and geography) in Cracow and Ingolstadt. Other universities in central Europe were to follow these examples.[71]

The impact of the humanist movement in teaching was of course felt in many ways. Here it may suffice to note that the use of models such as celestial and terrestrial globes helped to put into practice the humanist's emphasis on the importance of understanding. It is not a coincidence that the first records of the use of a terrestrial globe in teaching is associated with Conrad Celtis, the famous humanist and founder of the Collegium der Poeten und Mathematiker at the University of Vienna in 1497. Celtis himself owned a terrestrial and a celestial globe, both of which he used for educational purposes during his cosmographic lectures.[72] Demonstration models were also used at the University of Ingolstadt, where Celtis had been lecturing in 1492 and in vain had tried to create an independent chair in mathematics. The records of the arts faculty there show that in 1487 a *sphaera* was available; in 1496/97 there was a *sphaera mundi,* and in 1511 a *corpus spericum.*[73] Also, outside Germany there is evidence of the use of globes in education, although at a much later date. In a rare picture drawn by a student in the margin of his notebook, the Jesuit priest J. C. Boulenger is shown using a globe during a lecture in 1588 (fig. 6.9).[74]

The use of three-dimensional models provided, among other things, a better understanding of problems related to spherical trigonometry. In general, lack of mathematical training had been a barrier for many in understanding the details of astronomy and geography. For instance, in a letter dated 3 March 1581 to Wolfgang Haller, a minister in Zurich, Mercator explains that he had followed a course on the theory of the planets by his honored countryman Gemma Frisius, but that the course had done him little good because he had not learned the necessary geometry in advance.[75]

The educational scope of three-dimensional demonstration models also included popular science as it developed in the sixteenth century. One of the booklets published in 1509 by Johann Grüninger mentions this purpose explicitly in the title: *Globus Mundi: Declaratio sive de-*

69. The symbolic meaning of globes is discussed by Schramm, *Sphaira, Globus, Reichsapfel;* Catherine Hofmann et al., *Le globe & son image* (Paris: Bibliothèque Nationale de France, 1995); Jan Mokre, "Immensum in parvo—Der Globus als Symbol," in *Modelle der Welt: Erd- und Himmelsgloben,* ed. Peter E. Allmayer-Beck (Vienna: Brandstätter, 1997), 70–87; and Kristen Lippincott, "Globes in Art: Problems of Interpretation and Representation," in *Globes at Greenwich,* 75–86.

70. See Schöner, *Mathematik und Astronomie,* 24–96, esp. 62–63, and, for a general history of the early universities, see Olaf Pedersen, *The First Universities:* Studium Generale *and the Origins of University Education in Europe* (Cambridge: Cambridge University Press, 1997).

71. See note 39 and Schöner, *Mathematik und Astronomie,* 66–71. It is not clear what type of armillary sphere was used by von Gmunden. Most early surviving three-dimensional models consist of a static sphere mounted on a handle; later spheres could be turned around in an adjustable meridian ring and a stand with a horizon ring, such as is used for the majority of globes made in Western Europe. The earliest armillary sphere of this kind is in the Museum for the History of Science, Oxford, and datable to sometime around 1425.

72. Ernst Bernleithner, in "Kartographie und Globographie an der Wiener Universität im 15. und 16. Jahrhundert," *Der Globusfreund* 25–27 (1978): 127–33, esp. 128, quotes from an announcement for lectures on the eight books of Ptolemy's *Geography:* "Because I taught the solid spheres of heaven and earth, and old maps, and new teachings." Bernleithner does not mention his source explicitly. Independent evidence on Celtis's globes is given in his will, dated 24 January 1508 and published in Conrad Celtis, *Der Briefwechsel des Konrad Celtis,* collected, edited, and with commentary by Hans Rupprich (Munich: C. H. Beck'sche, 1934), 604–9, esp. 605.

73. Schöner, *Mathematik und Astronomie,* 155–56.

74. François de Dainville, "Die Anschauungen der Globusliebhaber," *Der Globusfreund* 15–16 (1967): 193–223, esp. 196–97, fig. 58.

75. Gerardus Mercator, *Correspondance Mercatorienne,* ed. Maurice van Durme (Antwerp: De Nederlandsche Boekhandel, 1959), 166.

FIG. 6.9. J. C. BOULENGER WITH GLOBE. A drawing by a student of the Jesuit priest J. C. Boulenger, made during his lectures at Clermont College at Paris in 1588, viewing a globe and holding a pair of dividers.
Photograph courtesy of the BNF (Latin 10822, fol. 261v).

scriptio mundi et totius orbis terrarum, globulo rotundo comparati ut spera solida, qua cuivis etiam mediocriter docto ad oculum videre licet antipodes esse, quorum pedes nostris oppositi sunt (Terrestrial globe: Explanation or description of the world and the whole earth, prepared as a round globe corresponding to a massive sphere, whereby anyone can see, even those without advanced education, that there are antipodes whose feet are placed precisely opposite ours).[76]

The promoter par excellence of popular science inside and outside the university was Peter Apian, who had studied in Leipzig from 1516 until 1519 and later at the University of Vienna. His complete oeuvre is interspersed with all sorts of demonstration models of wood and paper in two and three dimensions to overcome mathematical barriers. One example is the model labeled "De speculo cosmograph[iae]" (Cosmographic mirror), described in his *Cosmographicus liber* of 1524 (see fig. 3.11). This paper instrument consists of a base plate, a volvelle with a printed map of the earth, and another movable part shaped as the rete of an astrolabe. In addition, around the north pole there is a small hour circle with an index arm and another index arm with a latitude scale, and both can rotate around the center. This instrument was included in all sixty or more editions of the book and must have been familiar to every student of the liberal arts in the sixteenth century. It was also added to a number of sixteenth-century editions of Sacrobosco's *Sphere*.[77]

With the help of Apian's paper instrument, a variety of cosmographic problems could be solved: locating a place on earth once the geographical longitude and latitude of a place was known; familiarizing students with the use of spherical coordinates; working out the relation between local times at different places, in which case the instrument served as an analog computer; or finding where on earth the sun appears at the zenith on certain days of the year to explain the concept of the zones. Later in the century, these problems became a standard part of globe manuals. The so-called Ingolstadt gores, attributed to Peter Apian and dated around 1527, which served as an illustration in his later works on cosmography, are another example.[78]

From an inventory of 1585 it appears that during his life Apian owned a celestial globe by Johannes Schöner, and several instruments and spheres of wood, for use in education. In 1585 these latter instruments were apparently in poor condition, and therefore it was thought best that they be burnt.[79] Many early Renaissance globes were probably lost in a similar way during the sixteenth century, for instance, the globes used by the Spanish mathematician and cosmographer Juan Bautista Gesio, who died in 1580. In his will "a terrestrial copper globe, much used and not worth any money," is mentioned together with "two celestial spheres and one terrestrial globe of paper, much worn, 'which instruments have been taxed and estimated at very low value, because they are almost all much used (ill treated), broken and damaged, and for that reason they have not yet been sold.'"[80]

76. Van der Krogt, *Globi Neerlandici,* 28.

77. Owen Gingerich, "Astronomical Paper Instruments with Moving Parts," in *Making Instruments Count: Essays on Historical Scientific Instruments Presented to Gerard L'Estrange Turner,* ed. R. G. W. Anderson, J. A. Bennett, and W. F. Ryan (Aldershot: Variorum, 1993), 63–74.

78. See appendix 6.1, no. 20, and Rüdiger Finsterwalder, "Peter Apian als Autor der sogenannten 'Ingolstädter Globusstreifen'?" *Der Globusfreund* 45–46 (1998): 177–86.

79. Wilhelm Füssl, "'Vil nit werth'? Der Nachlass Peter Apians im Streit der Erben," in *Peter Apian: Astronomie, Kosmographie und Mathematik am Beginn der Neuzeit,* ed. Karl Röttel (Buxheim: Polygon, 1995), 68–79, esp. 75.

80. Ursula Lamb, "Nautical Scientists and Their Clients in Iberia (1508–1624): Science from Imperial Perspective," *Revista da Universi-*

NAVIGATION

Globes also appear to have been extremely useful in navigation.[81] From the very moment that navigators started to cross deep waters, a new and better approach to navigation was needed. Well into the eighteenth century, position finding at sea continued to be based predominantly on directions and distances, but world navigators needed an understanding of the projection of the earth's spherical surface on a plane when plotting the results of their dead reckoning on a map. Moreover, where possible, they needed to develop methods to find and check the position of a ship in terms of the spherical coordinates of latitude and longitude. The need to find reliable ways to determine this latitude and longitude was a problem for navigators and mapmakers alike. Small wonder, then, that instruction in navigation included cosmography and the use of the globe.

To apply the newly developed science of navigation one had to learn how to find one's latitude by the so-called regiment of the sun, or the regiment of the Pole Star. To measure the variation of the compass one had to know how to determine the meridian line by solar observations, and to find the longitude of a place eclipses had to be understood. In addition, a navigator needed a sound knowledge of the doctrine of the sphere and the motions of the sun, the moon, and the stars. The first textbooks describing the regiment of the sun were in fact combined with a Portuguese translation of the 1488 edition of Sacrobosco's treatise the *Sphere*.[82] Another treatise of the sphere, *Tratado da sphera* (1537), enlarged with the first book of Ptolemy's *Geography* and other matters of navigational interest such as a discussion of rhumb lines, was published by Pedro Nunes, professor of mathematics at Coimbra University, one of the founders of nautical science, and, from 1529 until his death, royal cosmographer to the king of Portugal.

Although very little is known about the actual use of globes in this early period, as early as 1497 a terrestrial globe by John Cabot, the discoverer of Newfoundland, is recorded in England.[83] The presence of globes in navigational circles of Portugal and Spain is known from 1518, when Ferdinand Magellan presented his plan concerning the Moluccas, explaining, "Jorge [Reinel] . . . constructed among others a globe and a world map . . . ; these works had not been made by the arrival of the father, Pedro, who put the finishing touches and correctly situated the Moluccas."[84] Upon the return of the expedition, a globe (now lost) was made showing an itinerary that would have proved that the Moluccas lay in the Spanish zone.[85] According to Denucé, this globe and map served as models for all other cartographic products made, for instance, by Diogo Ribeiro, the first official cosmographer of the Casa de la Contratación in Seville, appointed in 1523.[86]

The sphericity of the earth became a matter of concern for finding one's way across the oceans, and it introduced new ideas in navigation. Questions arose, such as What is the shortest route between two points on the sphere? or What is the path traced by a ship sailing a constant course? The latter track, called a rhumb line or loxodrome, was not a straight line on a common plane map, nor did it coincide with a great circle on the globe. In 1537 the loxodromes as lines drawn on a globe were discussed by Nunes, and only four years later, in 1541, Gerardus Mercator presented them on his cosmographic globe (fig. 6.10 and app. 6.1, no. 39).[87] The depiction of rhumb lines on Mercator's globe was the first step in a process that ultimately resulted in the creation of his famous world map of 1569 "ad vsvm nauigantium" (for the use of navigators) in the projection that now carries his name. In retrospect, maps in this projection turned out to be far more important for the navigator than the presence of loxodromes on globes.[88] However important the concept of loxodromes is, it played a minor part in the practice of position finding at sea. The globe had more to offer for great circle sailing. The trick was to rectify the

dade de Coimbra 32 (1985): 49–61; reprinted in *Cosmographers and Pilots of the Spanish Maritime Empire,* by Ursula Lamb, item IX (Aldershot: Variorum, 1995), esp. 56.

81. The history of early navigation has been described extensively in the literature. See the relevant chapters in this volume and the references cited there. For globes in particular, see Elly Dekker, "The Navigator's Globe," in *Globes at Greenwich,* 33–43. See also David Watkin Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times,* 2d ed. (Greenwich: National Maritime Museum, 1978), 130, 140, 157, 193–97, and 207–8.

82. Joaquim Bensaúde, *L'astronomie nautique au Portugal à l'époque des grandes découvertes,* 2 vols. (Bern: M. Drechsel, 1912–17; reprinted Amsterdam: Meridian, 1967), 1:70 and 168–74.

83. Helen Wallis, "Globes in England Up to 1660," *Geographical Magazine* 35 (1962–63): 267–79, esp. 267–69; see also Edward Luther Stevenson, *Terrestrial and Celestial Globes: Their History and Construction Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy,* 2 vols. (New Haven: Yale University Press, 1921), 1:53.

84. Jean Denucé, *Magellan: La question des Moluques et la première circumnavigation du globe* (Brussels, 1911), 205–6; see also Stevenson, *Terrestrial and Celestial Globes,* 1:81–82.

85. Ursula Lamb, "The Spanish Cosmographic Juntas of the Sixteenth Century," *Terrae Incognitae* 6 (1974): 51–64; reprinted in *Cosmographers and Pilots of the Spanish Maritime Empire,* by Ursula Lamb, item V (Aldershot: Variorum, 1995), esp. 55.

86. Denucé, *Magellan,* 206.

87. Pedro Nunes [Nuñez], *Tratado em defensam da carta de marear* (Lisbon, 1537). This book was published together with Nunes's treatise on the sphere. See also Van der Krogt, *Globi Neerlandici,* 65–67.

88. Heinrich Averdunk and J. Müller-Reinhard, "Gerhard Mercator und die Geographen unter seinen Nachkommen," *Petermanns Mitteilungen, Ergänzungsheft,* 182 (1914): esp. 3–35 and 65–75, and Gerardus Mercator, *Gerard Mercator's Map of the World (1569),* intro. B. van 't Hoff (Rotterdam: Maritiem Museum, 1961). See figure 10.12 in this volume.

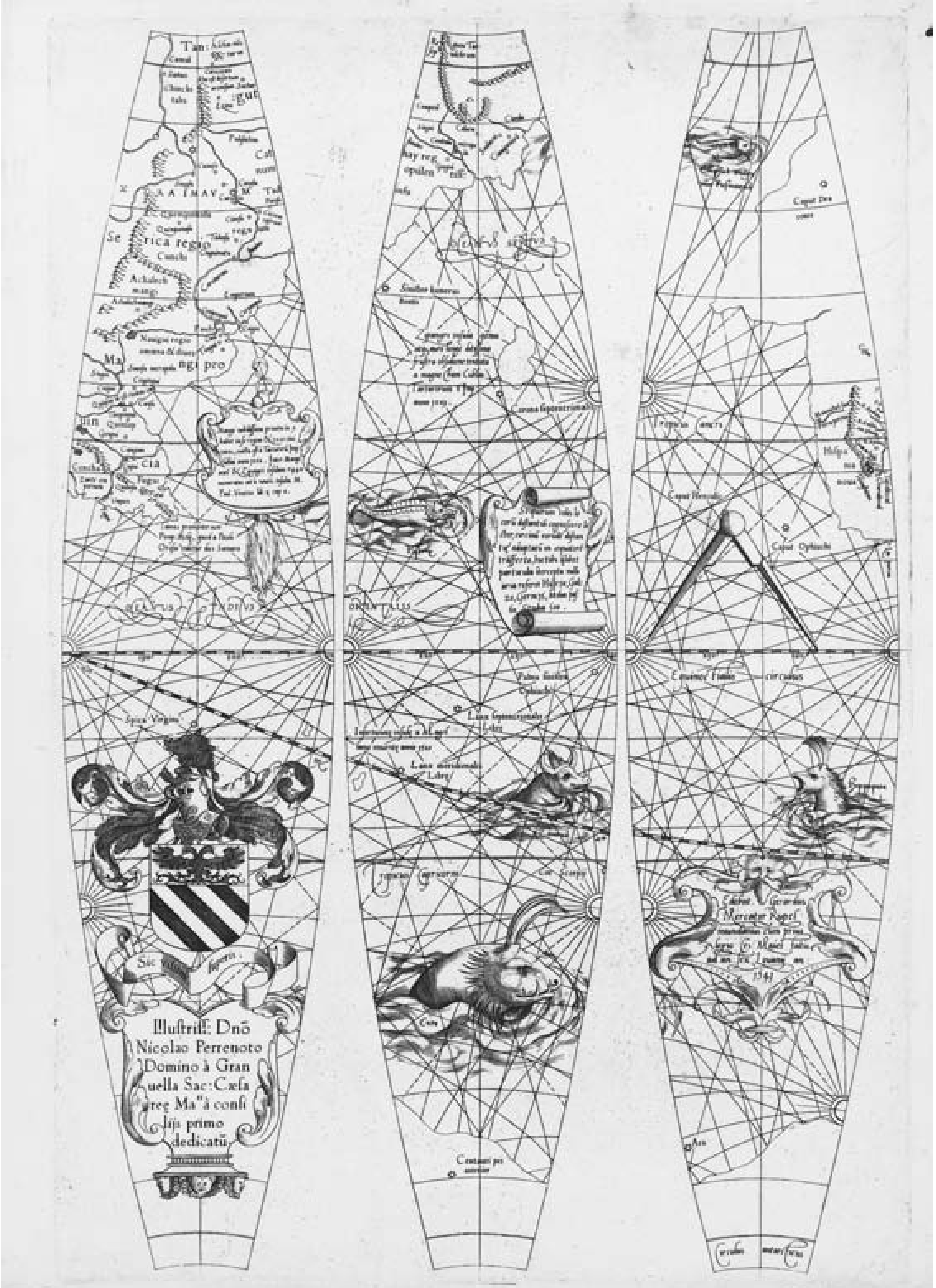

FIG. 6.10. COSMOGRAPHIC GLOBE GORES. A sheet of the facsimile gores made from the original set of printed gores (copper-engraved) for a cosmographic globe of 1541 by Gerardus Mercator. The sheet shows loxodromes drawn for thirty-two compass directions and also a number of stars. (See also p. 1360.)
Diameter of the mounted globe: ca. 42 cm. Photograph copyright Royal Library of Belgium, Brussels (Section des cartes et plans, III t.).

terrestrial globe for the ship's position so that the actual position of the ship would be found on top, at the zenith. With the help of the quadrant of altitude, the course for the ship's destination could subsequently be determined.

The usefulness of globes at sea has been a matter of debate among historians. Considering that there are no records to show that globes were actually employed at sea for position finding, this debate will not easily be resolved. Sixteenth-century navigators were divided among themselves on the matter of the globe's usefulness at sea, especially in England. William Borough did not advise the use of globes at sea, estimating that it was too difficult to manipulate them. Others, such as Robert Hues and John Davis, strongly defended the merits of the globe for navigation purposes. As a result of Davis's enthusiasm in particular, the first pair of printed globes was published in London by Emery Molyneux in 1592.[89] At the request of William Sanderson, a wealthy merchant and financier of the publication of the Molyneux globes, Thomas Hood, the "Mathematicall Lecturer in the Citie," wrote a treatise concerning the use of the globes. As Waters observed: "The need for such a treatise was real enough, for the globes were now, as Hood put it, 'in the handes of many with whome I have to do.'"[90]

In 1587 Hood had already been commissioned by Thomas Smith and John Wolstenholme, city financiers and promoters of marine enterprise, to give public lectures in the Leadenhall on the application of mathematics to navigation. Hood's popular treatise on the use of globes, written in dialogue form, was overshadowed two years later, in 1594, when a manual on globes was published by Robert Hues, a mathematician and geographer who had accompanied Thomas Cavendish on his voyage around the world in 1586–88.[91] Hues wrote in Latin for educated readers interested in navigation, witness of which is his chapter on rhumbs and their use, the first one with instructions for their practical use at sea. His manual was translated into Dutch to accompany a new pair of globes published by Jodocus Hondius in Amsterdam in 1597.[92] Hondius had engraved the Molyneux globes and was well acquainted with navigation circles in London. In text following the title of this Dutch translation of Hues's manual, the use of globes in navigation is strongly advocated: "In this treatise not only the use of the globe is discussed for astronomy, geography and comparable pleasant arts: *But mainly for Seafaring, for which an explanation is given of the rhumbs and their use.*"[93] By then John Davis had published his *Seamans Secrets,* which also included a chapter on globes.[94]

Thus around 1600 a number of globe manuals in the vernacular were available to teach the use of globes at sea. Still, only highly skilled navigators like Davis succeeded to make good use of globes in position finding. Most navigators preferred more practical methods for finding their way across the ocean. As a result, the prospect of the terrestrial globe as a navigational tool diminished, then came to an end sometime around 1650. This is not to say that loxodromes also disappeared from the surface of globes. To the contrary, loxodromes continued to be included on terrestrial globes and served as an icon symbolizing the significance of navigation for globemaking rather than the other way around.

ASTROLOGY

Alongside his well-known treatises on astronomy and geography, Ptolemy wrote a third work, which also enjoyed a quasi-biblical authority: *Tetrabiblos* (Mathematical treatise in four books). In the introduction to this work, the author explains that next to the study of "the aspects of the movements of sun, moon, and stars in relation to each other" (astronomy proper) and to the earth (geography), there is another astronomy (astrology) "in which by means of the natural character of these aspects themselves we investigate the changes which they bring about in that which they surround."[95]

The use of celestial globes to find the right moment for acting or decision making according to astrological doctrine had already been proposed in the early fourteenth century by John of Harlebeke, who criticized Ptolemy's description of the celestial globe in the *Almagest* because he had not intimated "how this instrument might be brought to perfection so that it could be put to everyday uses, i.e. (finding) ascendants, equations of the houses, and other things necessary in this application (i.e. astrology)."[96] The use of the globe for astrological purposes

89. For Molyneux's globe, see Helen Wallis, "The First English Terrestrial Globe," *Der Globusfreund* 11 (1962): 158–59 (in English and German), and idem, "'Opera Mundi': Emery Molyneux, Jodocus Hondius and the First English Globes," in *Theatrum Orbis Librorum: Liber Amicorum Presented to Nico Israel on the Occasion of His Seventieth Birthday,* ed. Ton Croiset van Uchelen, Koert van der Horst, and Günter Schilder (Utrecht: HES, 1989), 94–104.

90. Waters, *Art of Navigation,* 185–96, quotations on 186 and 189–90.

91. Robert Hues, *Tractatvs de globis et eorvm vsv* (London, 1594). An English translation was published by John Chilmead: Robert Hues, *A Learned Treatise of Globes: Both Cœlestiall and Terrestriall. With Their Several Uses* (London, 1639). This English edition was also published as *Tractatus de globis et eorum usu: A Treatise Descriptive of the Globes Constructed by Emery Molyneux, and Published in 1592,* ed., with annotated indexes and introduction, by Clements R. Markham (London: Hakluyt Society, 1889).

92. For Hondius's globes, see Van der Krogt, *Globi Neerlandici.*

93. Robert Hues, *Tractaet: Ofte Handelinge van het Gebruijck der Hemelscher ende Aertscher Globe,* ed. and trans. Jodocus Hondius (Amsterdam, 1597), title page (my italics).

94. John Davis, *The Seamans Secrets* (London: Thomas Dawson, 1595), pt. 2.

95. Claudius Ptolemy, *Tetrabiblos,* ed. and trans. Frank Egleston Robbins (1940; reprinted Cambridge: Harvard University Press, 1964), 3.

96. Lorch, "*Sphera Solida,*" 156.

FIG. 6.11. CELESTIAL GLOBE FROM STÖFFLER'S WORKSHOP. The globe was made in 1493 in the workshop of Johannes Stöffler, an astronomer and instrumentmaker who was professor of mathematics at the University of Tübingen. The metal grid surrounding the globe is for astrological purposes such as making horoscopes.
Size of the original: diameter 49 cm; height 107 cm. Photograph courtesy of the Germanisches Nationalmuseum, Nuremberg (inv. no. WI 1261).

was still current in the second half of the seventeenth century when Joseph Moxon discussed the practice in his treatise on globes.[97] By then, however, astrology was on the decline as a serious scientific subject, and by the eighteenth century no more was heard of the astrological usefulness of globes. The most notable of the globemakers of the sixteenth century—Johannes Stöffler, Johannes Schöner, Gemma Frisius, and Gerardus Mercator—all practiced astrology and through the production of their celestial globes helped to promote it.

Astrology is the key to understanding the celestial globe made by Johannes Stöffler.[98] This globe stands out because of the device added to it for finding the astrological houses for a given place and time of birth (fig. 6.11). Its use simplified the complicated calculations needed to prepare a horoscope or to determine, say, the right moment for marriage. The globe by Stöffler was made for the bishop of Constance, Daniel Zehender, who certainly was not alone in his interest in astrology. A prominent figure in this respect was Philipp Melanchthon, who studied in Tübingen where Stöffler was professor of mathematics and astronomy from 1507. Under Stöffler's influence, as he acknowledged on several occasions, Melanchthon acquired, in addition to a knowledge of astronomy, mathematics, and geography, a strong belief in astrology.[99] Between 1535 and 1545, Melanchthon lectured about the *Tetrabiblos,* and he prepared a Latin translation of it that was published in 1553 alongside the second Greek edition by Joachim Camerarius.[100] With Johannes Schöner, a most prolific author in astrology, Melanchthon is said to have selected a favorable astrological moment for the foundation of the gymnasium in Nuremberg (later the Melanchthon Gymnasium), where Schöner was professor in mathematics from 1526.[101] And although there is no documentary evidence that Melanchthon used a globe for astrological purposes, he was so well acquainted with globemakers such as Schöner and Mercator that it is almost unthinkable that he would not have possessed one or more of their globes.

Astrology is also at the background of the celestial globes of Gemma Frisius and Gerardus Mercator.[102] Gemma is often considered a mathematician, astronomer, or geographer. On his celestial globe, however, he calls himself *medicus ac mathematicus,* in that order. His medical association explains why Gemma published a celestial globe for astrological applications a year after his cosmographic globe.[103] Medicine and astrology were closely linked according to the macrocosmic/microcosmic theory of the elements and humors. And Mercator appears to have followed Gemma's example. On both globes the astrological nature of many stars has been indicated in terms

97. Joseph Moxon, *A Tutor to Astronomy and Geography; or, An Easie and Speedy Way to Know the Use of Both the Globes, Cœlestial and Terrestrial* (London, 1659, 1670, 1674, and 1686), 122–35. I used the facsimile of the 1674 edition dedicated to Samuel Pepys (New York: Burt Franklin, 1968).

98. See appendix 6.1, no. 5, and Günther Oestmann (with contributions by Elly Dekker and Peter Schiller), *Schicksalsdeutung und Astronomie: Der Himmelsglobus des Johannes Stoeffler von 1493,* exhibition catalog (Stuttgart: Württembergisches Landesmuseum, 1993).

99. Oestmann, *Schicksalsdeutung und Astronomie,* 8 and 18 n. 43.

100. Ptolemy, *Tetrabiblos,* xi.

101. Thorndike, *Magic and Experimental Science,* 5:393.

102. See appendix 6.1, nos. 35 and 58, and Annelies van Gijsen, "De astrologie," in *Gerardus Mercator Rupelmundanus,* ed. Marcel Watelet (Antwerp: Mercatorfonds, 1994), 220–33. A French edition of this book appeared as Marcel Watelet, ed., *Gerard Mercator, cosmographe: Le temps et l'espace* (Antwerp: Fonds Mercator Paribas, 1994).

103. The celestial globe of Gemma is discussed in Elly Dekker, "Uncommonly Handsome Globes," in *Globes at Greenwich,* 87–136, esp. 87–91.

of the corresponding nature of the planets. The astrological information on Gemma's globe included data from a fourteenth-century Arabic tradition. In contrast, the data used by Mercator stems from contemporary sources, such as the Greek edition of the *Tetrabiblos* edited and translated by Joachim Camerarius (first published in Nuremberg in 1535) and the *De supplemento almanach* of Hiëronymus Cardanus (Girolamo Cardano) (first published in Milan in 1538 and reprinted in Nuremberg in 1543). Additional astrological information, such as the astrological houses and their relation to the planets, was provided on the horizon ring of Mercator's celestial globe. It is clear that Mercator's celestial globe would have eminently suited the demands of a student of astrology.

The use of planetary positions in astrology called for precise positions of the fixed stars, because the locations of the planets were determined by their distance from one or two fixed stars. For this reason Mercator's celestial globe was also to be preferred above others at the time because, next to up-to-date information about the nature of the stars and planets, the positions of the stars were fixed according to a new theory of precession published by Nicolaus Copernicus in his *De revolutionibus* of 1543. Mercator was the first among the globemakers to have used this theory.[104] Small wonder, then, that the mathematician, geographer, and occult philosopher John Dee, a good friend of Mercator, was very pleased to have in his library as early as 1555 "Two Globes of Gerardus Mercator's best making on which were my divers reformations, both Geographical and Celestial."[105] What these "reformations" were is not known, but they may well have been astrological. In 1558 Dee was taken into the service of the court of Queen Elizabeth I and called upon to calculate astrologically a suitable day for her coronation.[106]

Astrology was very popular, and not only among the nobility. The citizens of Nuremberg, such as humanists Lorenz Behaim and Willibald Pirckheimer, were also greatly interested in it. It was for astrology that in 1517 Behaim bought a printed celestial globe and an accompanying booklet by Johannes Schöner for which he paid 2½ gulden.[107] The activities of Johannes Schöner and Joachim Camerarius have already been mentioned. Proof of astrological interest is also evident in the beautiful pair of gilt globes made in 1566 by the mathematician and astronomer Johannes Prätorius and the goldsmith Hans Epischofer (app. 6.1, nos. 75 and 76). These globes are part of a collection of instruments that were ordered by the physician Melchior Ayrer to serve the astrological interests of his medical profession.[108]

GLOBES AT COURT

Last but not least among the users of globes were those who could afford grand and richly decorated globes. "Globes of copper, bronze or silver," as Girolamo Ruscelli explains in his translation of Ptolemy's *Geography,* "such as princes would desire to possess, to be fine, durable and rare should be plated, that is, the circles, the letters, the outlines of the countries should first be engraved and then there should be added gold or silver plating."[109]

In the sixteenth century such globes could indeed be found in the cabinets of the nobility and in the collections of wealthy merchants. Well-known examples are the clockwork-driven globes with inlaid enamel made by Georg Roll and Johann Reinhold for Rudolf II in Prague and his brother, Archduke Ernst.[110] These globes consist of a small terrestrial globe placed below a larger celestial globe, with either an armillary sphere or an ornament on top of the meridian ring around the celestial globe. Another treasure in Rudolf's "Kunstkammer" (these "cabinets of curiousities" were also called "Wunderkammern") was a silver clockwork-driven celestial globe carried by Pegasus that was made by Gerhard Emmoser in 1579.[111] The globes of Roll and Reinhold and of Emmoser are part of a clockmaker's tradition rather than a mapmaking tradition. As the workmanship required for making such precious globes is at the periphery of the world of the cosmographer, the craftsmen often copied the actual mappings from simple models. The globes of Roll and Reinhold and of Emmoser, for instance, as far as their mapping is concerned, are copies of the simple printed globes produced by the French mathematician François Demongenet, who was not really at the head of the profession of globemaking.[112]

Many a goldsmith can also be found among the makers of precious globes. Particularly precious are the so-called chalices or drinking globe-cups made by Stampfer in Basel (fig. 6.8) and Abraham Gessner in Zurich (fig. 6.12).[113] Of Gessner's globe-cups, sixteen have been preserved. All chalices consist of a terrestrial globe, made out

104. Elly Dekker, "Conspicuous Features on Sixteenth Century Celestial Globes," *Der Globusfreund* 43–44 (1995): 77–106 (in English and German), esp. 79–80.

105. Wallis, "Globes in England," 271.

106. Eric John Holmyard, *Alchemy* (1957; reprinted Harmondsworth: Penguin, 1968), 205.

107. Hauschke, "Globen und Wissenschaftliche Instrumente," 365.

108. *Focus Behaim Globus,* 2:637–45.

109. Stevenson, *Terrestrial and Celestial Globes,* 1:153.

110. *Prag um 1600,* 1:562–63.

111. *Prag um 1600,* 1:552. For clockwork globes and spheres, see Hans von Bertele, *Globes and Spheres* (Lausanne, 1961). The most detailed discussion on the clockwork of mechanical globes is by John H. Leopold, *Astronomen, Sterne, Geräte: Landgraf Wilhelm IV. und seine sich selbst bewegenden Globen* (Lucerne: J. Fremersdorf, 1986).

112. See Elly Dekker, "The Demongenet Tradition in Globe Making," in *Globes at Greenwich,* 69–74.

113. For Stampfer and Gessner, see Eva-Maria Lösel, *Zürcher Goldschmiedekunst: Vom 13. bis zum 19. Jahrhundert* (Zürich: Berichthaus, 1983), 42–53. For the globe by Stampfer, see appendix 6.1, no. 55; for Gessner's globes, see appendix 6.1, nos. 108–9, 112–14, 131, 139, 140, 153, 167–68, and 170–74.

FIG. 6.12. A CUP OF GILT SILVER IN THE SHAPE OF A TERRESTRIAL GLOBE. The cup was made in 1587 by Abraham Gessner, a goldsmith from Zurich.
Size of the original: diameter 18 cm; height when assembled: 54 cm. Photograph courtesy of the Kunsthistorisches Museum, Vienna (inv. no. KK 1182).

of two hemispheres that can be taken apart, which is often carried by a figure representing Atlas. The small armillary sphere (or celestial globe) on top of his terrestrial globes reminds the user of the cosmos at large.

In the period under study, large parts of Europe were governed by the emperor Charles V, whose interest in the sciences is illustrated by his financial support for the printing of Peter Apian's *Astronomicum Caesareum* (1540).[114] There are no documents recording that Charles V owned particularly luxurious globes, but it seems probable that he had a pair of Mercator's globes for which Mercator had written a manual titled "Declaratio insigniorum utilitatum quae sunt in globo terrestri, coelesti, et annulo astronomico."[115] It is certain that Mercator made a small terrestrial globe for Charles V to be included in a crystal celestial globe on top of a grand planetary clock. The latter was made by Giovanni Gianelli, a clockmaker from Milan.[116] In a letter written by Mercator to Melanchthon on 23 August 1554, Mercator

114. Schöner, *Mathematik und Astronomie,* 417.

115. Averdunk and Müller-Reinhard, "Gerhard Mercator," 35–40, and Robert W. Karrow, *Mapmakers of the Sixteenth Century and Their Maps: Bio-bibliographies of the Cartographers of Abraham Ortelius, 1570* (Chicago: For the Newberry Library by Speculum Orbis Press, 1993), 376–406, esp. 384–85.

116. Peter H. Meurer, "Ein Mercator-Brief an Philipp Melanchthon über seine Globuslieferung an Kaiser Karl V. im Jahre 1554," *Der Globusfreund* 45–46 (1997–98): 187–96. In Walter Ghim's *Vita Mercatoris* it is said that Mercator "constructed by order of the Emperor two small globes, one of purest blown crystal and one of wood. On the former, the planets and the more important constellations were en graved with a diamond and inlaid with shining gold." A. S. Osley, *Mercator: A Monograph on the Lettering of Maps, etc. in the 16th Century Netherlands with a Facsimile and Translation of His Treatise on the Italic Hand and a Translation of Ghim's* Vita Mercatoris (New York:

tells how he was summoned by Charles V to Brussels with this globe, how he admired the planetary clock driven by more than seven hundred geared wheels, and how they discussed such problems as finding the longitude.[117] Now one can only guess about the details of Gianelli's planetary clock. It might have been of the type made in 1555 by Philipp Immser in cooperation with Emmoser.[118] Like Stöffler's celestial globe (fig. 6.11), the one on top of Immser's machine has a structure for finding the astrological houses. Immser, a pupil of Stöffler and from 1531 until 1557 professor of mathematics and astronomy in Tübingen, initially intended his planetary clock for the astrologically minded Pfalzgraf Ottheinrich. However, the duke died before the clock was finished, so in the end it was bought by Emperor Ferdinand I, a brother of Charles V.

Very large globes were also made. One, a brass celestial globe of 1502 with a diameter of 69 centimeters, is of unknown provenance.[119] The largest globe of the sixteenth century, however, is the terrestrial globe with a diameter of a little over 2 meters attributed to Egnazio Danti from Florence and dating from 1567.[120] It can still be seen decorating the Guardaroba Nuova in the Palazzo Vecchio of Duke Cosimo I de' Medici, for whom it was made. But not all grand globes were made for courtly surroundings. The terrestrial and celestial globes made by Philipp Apian and Heinrich Arboreus respectively in 1576 and 1575, with a diameter of 76 centimeters apiece, were destined to adorn the newly founded library of Duke Albrecht V in 1576.[121] And the St. Gallen globe shown in plate 5, which is 121 centimeters in diameter, was acquired in 1595 by abbot Bernhard II for his monastery in St. Gallen.

GLOBES AS SYMBOLS

In his classic work *Sphaira, Globus, Reichsapfel,* Schramm showed that in antiquity the globe served as a symbol for the universe and was used as an attribute of the gods, especially Zeus. Roman emperors were depicted with it to express both their worldly power and their divine aspirations. This pagan, imperial sphere was converted into a truly Christian symbol by placing a cross on top of it. The Christian orb was carried by God the Father and by Christ, as many paintings testify. It also became one of the main insignia of emperors of the Holy Roman Empire. This regal orb, or *Reichsapfel* as it became known in the Renaissance, still represented the symbolic values attached to it in the Middle Ages, although its use was no longer limited to the Roman emperor.

Although the association of globes with power in the Renaissance followed the patterns established in earlier centuries for the most part, the actual image of the world was dramatically changed. The voyages of exploration and the humanist movement not only created a new way of looking at the world; it also changed the customary patterns of thinking about worldly power. New continents were discovered with different floras and faunas, and new and strange people were actually found living in the torrid zones, which had been believed to be uninhabitable and intemperate by the ancient philosophers. To learn about these new regions and to discover their scope for trade was a goal worthy of merchants' investments. To learn about these new people and to understand how life proceeded in remote places of the world became a goal worthy of princely and scholarly aspiration. All this fitted well into the patterns of another new world opened up by the humanist movement. Thus a new culture came into being in which the globe stood out as a symbol on a variety of levels. It induced fanciful constructions such as that of Duke Cosimo of Florence, who, according to Giorgio Vasari, "wished to put together once and for all these things both of heaven and of earth, absolutely exact and without errors, so that it might be possible to see and measure them separately and all together, according to the pleasure of those who delight in this most beautiful profession [cosmography] and study it." [122]

It is against this background that one must understand the widespread application of the globe in art as a symbol for power and learning, as well as for navigation. This also applies to the widespread presence of globes in the cabinets of princely and bourgeois collectors, in many an Italian *studiolo,* and in the libraries of universities.[123] Conversely, it created a whole new market to make printed globes for students and scholars and expensive manuscript globes for the very rich. This explains why the the artist's contribution to globemaking in the Renaissance can be seen as next to the successes of the conven-

Watson-Guptill, 1969), 183–94, esp. 186. On Giovanni Gianelli, see Stevenson, *Terrestrial and Celestial Globes,* 1:135–36.

117. Meurer, "Ein Mercator-Brief," 193.

118. The planetary clock with globe by Philip Immser is in Vienna, Technisches Museum für Industrie und Gewerbe, inv. no. 11.393. It is described by Oestmann in *Schicksalsdeutung und Astronomie,* 31–34.

119. See appendix 6.1, no. 7, and Adolphe Chapiro, Chantal Meslin-Perrier, and Anthony John Turner, *Catalogue de l'horlogerie et des instruments de précision: Du début du XVI^e^ au milieu du XVII^e^ siècle* (Paris, 1989), 116–21.

120. See appendix 6.1, no. 78, and Stevenson, *Terrestrial and Celestial Globes,* 1:158–63.

121. Alois Fauser, *Ältere Erd- und Himmelsgloben in Bayern* (Stuttgart: Schuler Verlagsgesellschaft, 1964), 48–51 and figs. 5 and 6; see also Alois Fauser, *Kulturgeschichte des Globus* (Munich: Schuler Verlagsgesellschaft, 1973), 84–91.

122. Giorgio Vasari, *Lives of the Painters, Sculptors and Architects,* 2 vols., trans. Gaston du C. de Vere, intro. and notes David Ekserdjian (London: David Campbell, 1996), 2:893.

123. David Woodward, *Maps as Prints in the Italian Renaissance: Makers, Distributors & Consumers* (London: British Library, 1996), esp. 75–102.

tional map and instrumentmakers. Together they stood at the base of a whole new industry that still prospers today.

Renaissance Globes: Humanism Materialized

Although editions of the *Sphere* of Sacrobosco were still common in the sixteenth century, the work did not enjoy the same popularity as it had during the Middle Ages.[124] As the impact of the translations of Ptolemy's *Geography* and the voyages of discovery was felt more and more, other treatises with more details of interest to geography and navigation became more prominent. Peter Apian's *Cosmographicus liber* is only one example of the new generation of university textbooks. Paper volvelles, or working illustrations with movable parts, which form so vivid a part of Apian's book and the many additions to it made by Gemma Frisius in later editions, appear to be a common feature of such new textbooks. The importance of astronomical phenomena for finding the geographical latitude and longitude of a place on earth encouraged the design and use of instruments. Even the most geographical of the books on Renaissance cosmography, that of Sebastian Münster, bears testimony to this.

The result of this development was that although the main contents of the new treatises were very much the same as that of Sacrobosco's *Sphere,* they had, first, a much better feeling for science, and, second, contents that were understood by a much larger number of people. Also, new solutions to old problems—such as the method for determining lunar distance introduced by Johannes Werner (1514) and the horological method for finding the longitude developed by Gemma Frisius (1530)—and new instruments were added to those already known. The production and use of globes was certainly instrumental in this respect. If Schöner is correct in his assessment that cosmography and instrumentmaking were without doubt the two most important topics in teaching mathematics in the circle of Conrad Celtis, the making of globes might well be interpreted as humanism materialized.[125] Although such a claim on behalf of the humanist movement may seem exaggerated, the specialists who came to the fore in this movement distinguished themselves in two ways: either they were well versed in mathematics, and therefore well equipped to apply the relevant knowledge to practical applications, or they were able to make complicated instruments and models. The sixteenth century was a very cosmographic century in which most efforts were directed toward *understanding* what had come down from antiquity and the Middle Ages. And all cosmographers would have agreed with Hues: "I hold it very superfluous to goe about to prove that a Globe is of a figure most proper and apt to expresse the fashion of the Heavens and Earth as being most agreeable to nature, easiest to be understood, and also very beautifull to behold."[126]

In the sixteenth century, astrology was still a vital part of astronomy, which made itself felt especially in the demands for accurate positions of the stars and the planets. It is for such reasons that globemakers, beginning with Gerardus Mercator, were quick to apply the new theory of precession published by Copernicus in 1543 in *De revolutionibus.* This underlines the point made by Goldstein that in the sixteenth century "the motion of the starry sphere was a recognized problem in the astronomical community whereas geocentrism was not."[127] However, it would be wrong to see the use of Copernicus's theory about the starry sky as an indication that globemakers adhered to the heliocentric ideas of Copernicus about the world as a whole.

The mixture of concepts underlying the common Ptolemaic globe came under attack only in the eighteenth century. As George Adams wrote: "Though globes have ever been considered as the best instruments for conveying general ideas of astronomy and geography, yet have they always been mounted in a way that must perplex and confuse the learner, and furnish him with ideas that are altogether false, and contrary to the nature of things."[128] It was especially the design of the common globe as it had been established during the Renaissance that was criticized, because by definition

> every place is always in the zenith of it's horizon, and the place and horizon always move together; but in the common globes the broad paper circle is only the horizon in one situation, that is, when the place is in the zenith; after having rectified the globe to the latitude, the moment you move the globe, the broad paper circle is no longer the horizon. . . . As if it were to multiply confusion, a circle is laid down on the terrestrial globe to represent the ecliptic, and used as such in solving problems upon the common globes, though it involves the pupil in numerous absurdities: thus having marked the sun's place in the ecliptic, and rectified

124. Francis R. Johnson, "Astronomical Text-Books in the Sixteenth Century," in *Science Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice Written in Honour of Charles Singer,* 2 vols., ed. Edgar Ashworth Underwood (London: Oxford University Press, 1953), 1:285–302.

125. Schöner, *Mathematik und Astronomie,* 257.

126. Hues, *Tractatus de globis et eorum usu,* 16.

127. Bernard R. Goldstein, "Historical Perspectives on Copernicus's Account of Precession," *Journal for the History of Astronomy* 25 (1994): 189–97, esp. 189.

128. George Adams, *Lectures on Natural and Experimental Philosophy, Considered in It's* [sic] *Present State of Improvement: Describing, in a Familiar and Easy Manner, the Principal Phenomena of Nature; and Shewing, That They All Co-operate in Displaying the Goodness, Wisdom, and Power of God,* 5 vols. (London: R. Hindmarsh, 1794), 4:197.

> the globe to the latitude, then turn the globe, and the sun and earth have a diurnal motion together.[129]

This criticism signaled the beginning of the decline of the traditional design of the Ptolemaic globe. But it was another century before it gave way to the modern globe that conforms to the Copernican hypothesis in which the sun is in the center of the universe and the diurnal motion is explained by the rotation of the earth around its own axis.[130] The reason for this delay is clear: for an understanding of the visible world, a geocentric globe is preferable. Even Copernicus always bore in mind that

> For us who are borne by the earth, the sun and the moon pass by,
> And the stars return on their rounds, and again they drop out of sight.[131]

129. Adams, *Natural and Experimental Philosophy,* 4:198–99.

130. Elly Dekker, "The Copernican Globe: A Delayed Conception," *Annals of Science* 53 (1996): 541–66.

131. Nicolaus Copernicus, *On the Revolutions,* ed. Jerzy Dobrzycki, trans. and with commentary by Edward Rosen (London: Macmillan, 1978), 51.

APPENDIX 6.1 List of Globes and Globe Gores Made in Europe from 1300 until 1600

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
1. Celestial, anonymous	Ca. 1325	M	27	Bernkastel-Kues, St. Nikolaus Hospital (Cusanusstift)	Hartmann (1919), 28–40; *Focus Behaim Globus* (1992), 2:508–9
2. Celestial, anonymous	Ca. 1450	M	17	Bernkastel-Kues, St. Nikolaus Hospital (Cusanusstift)	Hartmann (1919), 42–50; *Focus Behaim Globus* (1992), 2:509
3. Celestial, Hans Dorn	1480	M	40	Cracow, Museum of the Uniwersytetu Jagiellońskiego	Ameisenowa (1959); Zakrzewska (1965), 7–8
4. Terrestrial, Martin Behaim	1492	M	51	Nuremberg, Germanisches Nationalmuseum	Ravenstein (1908); *Focus Behaim Globus* (1992), 1:173–308 and 2:745–46; see also fig. 6.4
5. Celestial, Johannes Stöffler	1493	M	49	Stuttgart, Württembergisches Landesmuseum	*Focus Behaim Globus* (1992), 2:516–18; Oestmann (1993b); see also fig. 6.11
6. Terrestrial (Laon globe), anonymous	Ca. 1500	M	17	Paris, precise location unknown	Stevenson (1921), 1:51–52; Raemdonck (1968), 11
7. Celestial, anonymous	1502	M	69	Ecouen, Musée National de la Renaissance Château d'Ecouen	Duprat (1973), no. 210; Chapiro, Meslin-Perrier, and Turner (1989), 116–21
8. Terrestrial gores, Martin Waldseemüller	Ca. 1507	P	12	Munich, Bayerische Staatsbibliothek; Minneapolis, University of Minnesota, James Ford Bell Library	Shirley (2001), 28–29 (no. 26); see also fig. 6.5
9. Terrestrial (Hunt-Lenox globe), anonymous	Ca. 1510	M	13	New York Public Library	Stevenson (1921), 1:73–74; Yonge (1968), 81 and 82
10. Terrestrial (Jagiellonian globe), anonymous	Ca. 1510	M	7.3	Cracow, Museum of the Uniwersytetu Jagiellońskiego	Stevenson (1921), 1:74–75; Zakrzewska (1965), 8–9; *Focus Behaim Globus* (1992), 2:668–70
11. Terrestrial gores, Louis Boulengier	Ca. 1514	P	11	New York Public Library	Shirley (2001), 43 (no. 38)
12. Celestial gores, Johannes Schöner	Ca. 1515	P	28	Washington, D.C., Library of Congress	See fig. 6.6
13. Terrestrial, Johannes Schöner	Ca. 1515	P	28	Frankfurt, Historisches Museum; Weimar, Herzogin Anna Amalia Bibliothek	Kratzsch (1984), 6 and 16–17; Dolz (1994), 10–13; Glasemann (1999), 13–14
14. Terrestrial, Johannes Schöner	1520	M	87	Nuremberg, Germanisches National-museum	*Focus Behaim Globus* (1992), 2:673–74
15. Terrestial, Nicolaus Leopold of Brixen	1522	M	37	Present location unknown	Oberhummer (1926); Muris and Saarmann (1961), 73–76
16. Celestial, Nicolaus Leopold of Brixen	1522	M	37	Present location unknown	Oberhummer (1926); Muris and Saarmann (1961), 73–76
17. Celestial, anonymous	Ca. 1525	M	11	Private collection	Brink and Hornbostel (1993), 152

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
18. Terrestrial (Green globe), anonymous	Ca. 1525	M	25	BNF	Stevenson (1921), 1:76–77; Duprat (1973), no. 211
19. Celestial (after Johannes Schöner), anonymous	Ca. 1525	M	17.5	Paris, Bibliothèque Sainte-Geneviève	Duprat (1973), no. 110 (attributes the globe incorrectly to Oronce Fine and dates it 1553); Dekker (1999b)
20. Terrestrial gores, Peter Apian	Ca. 1527	P	10.5	BNF	Shirley (2001), 50 (no. 43); Finsterwalder (1998)
21. Terrestial, Robert de Bailly	1530	M	14	New York, Pierpont Morgan Library	Stevenson (1921), 1:105–6; Yonge (1968), 4–5
22. Celestial, Caspar Vopel	1532	M	28	Cologne, Kölnisches Stadtmuseum	Zinner (1967), 578
23. Terrestrial, Johannes Schöner	Ca. 1533	P	28	Weimar, Herzogin Anna Amalia Bibliothek	Kratzsch (1984), 6 and 18–19
24. Celestial, Johannes Schöner	Ca. 1533	P	28	Weimar, Herzogin Anna Amalia Bibliothek; London, Royal Astronomical Society (on loan to the Science Museum)	Kratzsch (1984), 6 and 20–21; *Focus Behaim Globus* (1992), 2:524–25; Lamb and Collins (1994), 20
25. Celestial (probably originally part of clockwork-driven armillary sphere), attributed to workshop of Julien and Guillaume Coudray and Jean Du Jardin	1533	M	26	Montreal, Stewart Museum	Dahl and Gauvin (2000), 38–42 and 152–53
26. Terrestrial gores, anonymous	Ca. 1535	P	35	Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Van der Krogt (1985–86), 111; Shirley (2001), 79–81 (no. 71)
27. Terrestrial (gilt globe), anonymous	Ca. 1535	M	22	BNF	Muris and Saarmann (1961), 109–10; Duprat (1973), no. 212; Fauser (1973), 64–67
28. Terrestrial (wooden globe), anonymous	Ca. 1535	M	21	BNF	Duprat (1973), no. 213
29. Terrestrial (Nancy globe), anonymous	Ca. 1535	M	15	Nancy, Musée Historique Lorrain	Stevenson (1921), 1:101–2; Duprat (1973), no. 209
30. Terrestrial (*marmor* [marble] globe), anonymous	Ca. 1535	M	12	Gotha, Schloßmuseum	Horn (1976), 13–18
31. Celestial, Caspar Vopel	1536	P	29	Cologne, Kölnisches Stadtmuseum	Dekker (1995), 95
32. Terrestrial, Caspar Vopel	1536	P	29	Tenri, Tenri Central Library	Shirley (2001), 82 (no. 73); Kawamura, Unno, and Miyajima (1990), 177
33. Terrestrial gores (fragment), Caspar Vopel	1536	P	29	Bath (UK), The American Museum in Britain	Shirley (2001), 82–83 (no. 74)

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
34. Cosmographic, Gemma Frisius, Gaspard van der Heyden, and Gerardus Mercator	Ca. 1536	P	37	Vienna, Collection of Rudolf Schmidt (on loan to the Österreichsische Nationalbibliothek)	Van der Krogt (1993), 53–55 and 410–11; Wawrik and Hühnel (1994), 14–16
35. Celestial, Gemma Frisius, Gaspard van der Heyden, and Gerardus Mercator	1537	P	37	London, National Maritime Museum	Van der Krogt (1993), 55–57 and 411–12; Dekker (1999a), 87–91 and 341–42
36. Celestial gores, Georg Hartmann	1538	P	20	Munich, Bayerische Staatsbibliothek; Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Fauser (1964), 97; Van der Krogt (1985–86), 104
37. Celestial gores (after Caspar Vopel)	Ca. 1540	P	28	Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Van der Krogt (1985–86), 112
38. Terrestrial (crystal, part of a triumphal column attributed to Giulio Romano)	Ca. 1540	M	Ca. 5	Florence, Museo degli Argenti	Soly (1999), 488
39. Cosmographic, Gerardus Mercator	1541	P	42	London, National Maritime Museum	Raemdonck (1968); Van der Krogt (1993), 62–67 and 413–15; Dekker (1999a), 91–95 and 412–13; see also fig. 6.10
40. Terrestrial (part of an armillary sphere by Caspar Vopel)	1541	P	7	Washington, National Museum of American History	Stevenson (1921), 1:113; Zinner (1967), 579; not recorded in Yonge
41. Terrestrial (part of an armillary sphere by Caspar Vopel)	1541	P	7	London, Science Museum	Zinner (1967), 579
42. Terrestrial (part of an armillary sphere by Caspar Vopel)	1542	P	7	UK, Private collection	Lamb and Collins (1994), 80
43. Terrestrial gores, Alonso de Santa Cruz	1542	M	Parchment sheets; 79 × 144 overall	Stockholm, Kungliga Biblioteket, Sveriges Nationalbibliotek	Stevenson (1921), 1:121–22
44. Terrestrial, Eufrosino della Volpaia	1542	M	39	New York Historical Society	Stevenson (1921), 1:117–20; Yonge (1968), 62
45. Terrestrial, Caspar Vopel	1542	P	29	Cologne, Kölnisches Stadtmuseum	Private communication
46. Terrestrial (part of an armillary sphere by Caspar Vopel)	1543	P	7	Copenhagen, Nationalmuseet	Kejlbo (1995), 43–47 and 208–9
47. Terrestrial (part of an armillary sphere by Caspar Vopel)	1543	P	7	Washington, D.C., Library of Congress	Yonge (1968), 99

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
48. Terrestrial, Caspar Vopel	1544	P	28	Salzburg, Carolino Augusteum Salzburger Museum für Kunst und Kulturgeschichte	Allmayer-Beck (1997), 141–42 and 353
49. Terrestrial (part of an armillary sphere by Caspar Vopel)	1544	P	7	Formerly in the collection of Jodoco Del Badia of Florence; present location unknown	Stevenson (1921), 1:115–16
50. Terrestrial (part of an armillary sphere by Caspar Vopel)	1545	P	7	Munich, Deutsches Museum	Fauser (1964), 137
51. Celestial, Jacob Rabus	1546	M	17	Harburg, Fürstl. Oettingen-Wallerstein'sche Sammlung	Fauser (1964), 119
52. Celestial gores, Georg Hartmann	1547	P	8.4	Munich, Bayerische Staatsbibliothek; Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Fauser (1964), 97; Van der Krogt (1985–86), 104
53. Terrestrial gores, Georg Hartmann	1547	P	8.4	Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Van der Krogt (1985–86), 103–4; Shirley (2001), 79 and 82 (no. 72)
54. Terrestrial, French, anonymous	Ca. 1550	M	12	London, National Maritime Museum	Dekker (1999a), 100–101 and 200–201
55. Cosmographic globe-cup, Jakob Stampfer	Ca. 1550	M	14	Basel, Historisches Museum	Kish (1969–71); Nagel (1995); Lösel (1983), 295e; see also fig. 6.8
56. Celestial and terrestrial (part of clockwork-driven armillary sphere by Pierre de Fobis)	Ca. 1550	M	C = 15.5 T = 8	Formerly Rothschild Collection; exhibited in Vienna, Kunsthistorisches Museum, Kunstkammer	King and Millburn (1978), 76–77; Allmayer-Beck (1997), 136 and 333; Christie, Manson and Woods (1999), 304–8; Kugel (2002), 144–51
57. Terrestrial (Lécuy or Rouen globe), anonymous	Ca. 1550	M	25.5	BNF	Duprat (1973), no. 214; for the date, see Dörflinger (1973), 95–96
58. Celestial, Gerardus Mercator	1551	P	42	London, National Maritime Museum	Raemdonck (1968); Van der Krogt (1993), 67 and 413–15; Dekker (1999a), 91–95 and 413–15
59. Terrestrial gores, François Demongenet	1552	P	Ca. 9	New York Public Library	Stevenson (1921), 1:147–48; Yonge (1968), 90; Shirley (2001), 106 (no. 93)
60. Celestial gores, François Demongenet	1552	P	Ca. 9	New York Public Library	Stevenson (1921), 1:147–48; Yonge (1968), 90
61. Terrestrial, Jacques de la Garde	1552	M	12	London, National Maritime Museum	Dekker (1999a), 199–200

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
62. Terrestrial globe, attributed to Jacques de la Garde	Ca. 1552	M	6.2	Present whereabouts unknown	Kugel (2002), 46–49
63. Celestial (part of a planetary clock), Philipp Immser	1554/61	M	18	Vienna, Technisches Museum	Oestmann (1993b), 31–34; Allmayer-Beck (1997), 338
64. Celestial, Tilemann Stella	1555	P	28	Weissenburg, Römermuseum	Dekker (1995), 96
65. Terrestrial gores, Antonio Floriano	Ca. 1555	P	26	Rotterdam, Maritiem Museum	Van der Krogt (1984), 125–26
66. Terrestrial, Paolo Forlani	Ca. 1560	M	10	Cambridge, Whipple Museum of the History of Science	Dekker and Van der Krogt (1993), 20–21
67. Terrestrial gores, François Demongenet	Ca. 1560	P	8	Stuttgart, Württembergische Landesbibliothek, Nicolai Collection	Van der Krogt (1985–86), 107–8; Shirley (2001), 120–21 (no. 105)
68. Terrestrial, François Demongenet	Ca. 1560	P	8	Rome, Museo Astronomico e Copernicano	Calisi (1982), 70
69. Celestial gores, François Demongenet	Ca. 1560	P	8	Stuttgart, Württembergische Landesbibliothek, Nicolai Collection; Vienna, Collection Rudolf Schmidt	Van der Krogt (1985–86), 109; private communication
70. Celestial, François Demongenet	Ca. 1560	P	8	Rome, Museo Astronomico e Copernicano	Calisi (1982), 69
71. Terrestrial (part of a table clock), Jean Naze	Ca. 1560	M	6.5	Kassel, Staatliche Kunstsammlungen Kassel	Kummer (1983), 55; Mackensen (1982), 150–51
72. Terrestrial of Erik's "Reichsapfel," Cornelis Verweiden	1561	M	Not known	Stockholm, Kungliga Slottet, Husgeråds-kammaren	Schramm (1958), 145
73. Celestial (part of a planetary clock), Eberhard Baldewein and Hermann Diepel	1561/2	M	24	Kassel, Staatliche Kunstsammlungen Kassel	Leopold (1986), 61–64; Mackensen (1982), 118–21
74. Celestial, Johannes Prätorius	1565	M	28	Vienna, Sammlung des Fürsten von Lichtenstein	Allmayer-Beck (1997), 165, 166, and 345
75. Terrestrial, Johannes Prätorius and Hans Epischofer	1566	M	28	Nuremberg, Germanisches Nationalmuseum	*Focus Behaim Globus* (1992), 2:638–40
76. Celestial, Johannes Prätorius and Hans Epischofer	1566	M	28	Nuremberg, Germanisches Nationalmuseum	*Focus Behaim Globus* (1992), 2:637–38
77. Celestial (part of planetary clock), Eberhard Baldewein and Hermann Diepel	1566/7	M	29	Dresden, Staatlicher Mathematisch-Physikalischer Salon	Leopold (1986), 65–70

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
78. Terrestrial, Egnazio Danti	1567	M	204	Florence, Palazzo Vecchio	Del Badia (1881); Muris and Saarmann (1961), 145
79. Terrestrial, Johannes Prätorius	1568	M	28	Dresden, Staatlicher Mathematisch-Physikalischer Salon	Dolz (1994), 19–21
80. Terrestrial globe inside a (clockwork) celestial globe by Christian Heiden	1570	M	T = 10.5 C = 9	Vienna, Schatzkammer des Deutschen Ordens	Leopold (1986), 76–85
81. Terrestrial, Francesco Basso	1570	M	56	Turin, Biblioteca Nazionale	Muris and Saarmann (1961), 145
82. Terrestrial globe, anonymous	Ca. 1570	M	12	Private collection	Dekker and Van Laere (1997), 13–14 (1.10); Dekker (1999a), 70, table 7.1, PCI; Kugel (2002), 50–55
83. Terrestrial globe, anonymous	Ca. 1570	M	12	Present whereabouts unknown	Dekker (1999a), 70, table 7.1, PCII
84. Terrestrial, Giulio Sanuto and Livio Sanuto	Ca. 1570	P	69	Berlin, Staatsbibliothek	Dekker and Van der Krogt (1993), 32; Woodward (1987)
85. Celestial, Giovanni Antonio Vanosino	Ca. 1570	M	95	Vatican City, Vatican Museum	Hess (1967), 407–8; *Manoscritti cartografia* (1981), 61; Dekker (1999a), 72–73
86. Celestial (part of the Strassbourg clock), Isaac Habrecht (I)	1570	M	86	Strasbourg, Musée des Beaux-Arts	Beyer, Bach, and Muller (1960); Oestmann (1993a), 92–97 and pls. 23–24
87. Celestial globe, attributed to Vicenzo de' Rossi	Ca. 1570	M	12	Present whereabouts unknown	Kugel (2002), 30–32
88. Terrestrial (part of an armillary sphere), Josiah Habrecht	1572	M	5	Copenhagen, Nationalmuseet	Kejlbo (1995), 72–75 and 190–91
89. Celestial (clockwork is lost), Eberhard Baldewein	1574/75	M	14	Vienna, Kunsthistorisches Museum, Kunstkammer	Leopold (1986), 88–92; Allmayer-Beck (1997), 324; Kugel (2002), 152–57
90. Celestial (with clockwork), Eberhard Baldewein	1575	M	33	London, British Museum (loan from a private collection)	Leopold (1986), 93–102
91. Celestial, Christoph Schissler	1575	M	42	Sintra, Palácio Nacional	Reis (1990)
92. Celestial, anonymous	1575	M	71	Rome, Biblioteca Nazionale Centrale	Fiorini (1899), 187
93. Celestial globe, anonymous	Ca. 1575	M	Not known	Angers, Museé d'Angers	Private communication
94. Terrestrial, anonymous	1575	M	71	Rome, Biblioteca Nazionale Centrale	Fiorini (1899), 187
95. Cosmographic (St. Gallen globe), anonymous	Ca. 1575	M	121	Zurich, Schweizerisches Landesmuseum	Grenacher (1961); Fauser (1973), 96 and 99; see also plate 5

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
96. Celestial, Heinrich Arboreus	1575	M	76	Munich, Bayerische Staatsbibliothek	Fauser (1964), 50–51; Fauser (1973), 88–91; Wolff (1989)
97. Terrestrial, Philipp Apian	1576	M	76	Munich, Bayerische Staatsbibliothek	Fauser (1964), 48–49; Fauser (1973), 84–87; Wolff (1989)
98. Terrestrial gores, Mario Cartaro	1577	P	16	Chicago, Newberry Library	Shirley (2001), 160–61 (no. 137)
99. Terrestrial, Mario Cartaro	1577	P	16	Rome, Museo Astronomico e Copernicano	Calisi (1982), 70
100. Celestial, Mario Cartaro	1577	P	16	Florence, Istituto e Museo di Storia della Scienza; Rome, Museo Astronomico e Copernicano	Calisi (1982), 70 and 72; Miniati (1991), 42; Dekker (2004), 118–20
101. Celestial (with clockwork), Gerhard Emmoser	1579	M	14	New York, Metropol-itan Museum of Art	Leopold (1986), 104–11
102. Celestial globe, anonymous	1579	M	44	Milan, Museo Bagatti Valsecchi	Private communication
103. Cosmographic (Murad III), attributed to workshop of Gerardus Mercator	1579	M	30	Private collection; present whereabouts unknown	Christie, Manson and Woods (1991)
104. Celestial (Murad III), attributed to workshop of Gerardus Mercator	1579	M	30	Private collection; present whereabouts unknown	Christie, Manson and Woods (1991)
105. Terrestrial globe, anonymous	1579	M	44	Milan, Museo Bagatti Valsecchi	Private communication
106. Terrestrial, anonymous (formerly attributed to Hans Reimer)	Ca. 1580	M	2.5	Munich, Schatzkammer der Residenz	Fauser (1964), 120–21; Fauser (1973), 92–95
107. Celestial, anonymous (formerly attributed to Hans Reimer)	Ca. 1580	M	2.5	Munich, Schatzkammer der Residenz	Fauser (1964), 121; Fauser (1973), 92–95
108. Terrestrial globe-cup with a small armillary sphere on top, Abraham Gessner	Ca. 1580	M	17	Present whereabouts unknown	Schmidt (1977), 18–20; Lösel (1983), 196–97p; Kugel (2002) 60–67
109. Terrestrial globe-cup with a small armillary sphere, attributed to Abraham Gessner	Ca. 1580	M	18.5	Copenhagen, Nationalmuseet	Kejlbo (1995), 103, 105–8, 188–89; Lösel (1983), 1960
110. Terrestrial, anonymous	Ca. 1580	M	24	Darmstadt, Hessisches Landesmuseum	Kummer (1980), 99–101
111. Terrestrial globe, anonymous	Ca. 1580	M	2.5	Present whereabouts unknown	Kugel (2002), 56–59

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
112. Terrestrial globe-cup with a small armillary sphere by Abraham Gessner	Ca. 1580	M	Height, 41.5	Nancy, Musée Lorrain	Lösel (1983), 198z
113. Terrestrial globe-cup (small sphere missing) by Abraham Gessner	Ca. 1580 (a plate underneath the pedestal has 1569 engraved on it)	M	Height, 35; diameter, 15	London, British Museum	Lösel (1983), 198a1
114. Terrestrial globe-cup with a small armillary sphere by Abraham Gessner	Ca. 1580	M	17	Genève, Musée de l'Histoire des Sciences	Kugel (2002), 72
115. Celestial globe (with clockwork), attributed to Johann Reinhold	Ca. 1580	M	21	Present whereabouts unknown	Kugel (2002), 158–165
116. Celestial globe (part of an armillary sphere), anonymous	Ca. 1580	M	13.5	Nuremberg, Germanisches Nationalmuseum	*Focus Behaim Globus* (1992), 2:549; Dekker (1999a), 74 n.16
117. Celestial globe, anonymous	Ca. 1580	M	17	Present whereabouts unknown	Kugel (2002), 32–34
118. Celestial (with clockwork), anonymous	Ca. 1580	M	24	Darmstadt, Hessisches Landesmuseum	Kummer (1980), 101–3
119. Celestial, anonymous	Ca. 1580	M	51	Kaiserslautern, Pfalzgalerie	Kummer (1992), 110–11
120. Celestial (with clockwork) by Jost Bürgi	1582	M	23	Paris, Conservatoire National des Arts et Métiers (CNAM)	Duprat (1973), no. 41; Leopold (1986), 125–35
121. Celestial (with clockwork) and terrestrial, Johann Reinhold and Georg Roll	1584	M	C = 21 T = 9	Vienna, Kunsthistorisches Museum, Kunstkammer	King and Millburn (1978), 83–84; *Prag um 1600* (1988), 1:562–63; Allmayer-Beck (1997), 136 and 348
122. Celestial (with clockwork), Johann Reinhold and Georg Roll	1584	M	Not known	London, Victoria and Albert Museum	King and Millburn (1978), 84; *Prag um 1600* (1988), 562
123. Celestial (with clockwork) and terrestrial, Johann Reinhold and Georg Roll	Ca. 1584	M	C = 21 T = 9	St. Petersburg, State Hermitage Museum	*Prag um 1600* (1988), 562
124. Celestial, attributed to Giovanni Battista Fontana	Ca. 1585	P	18	Innsbruck, Schloß Ambras	Dekker (1995), 97; Allmeyer-Beck (1997), 333

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
125. Terrestrial gores, attributed to Gerard de Jode	Ca. 1585	P	73.5	BNF	Shirley (2001), 176–78 (no. 156); Van der Krogt (1993), 253–57 and 416; see also fig. 44.44
126. Celestial (with clockwork), Jost Bürgi	Ca. 1585	M	23	Weimar, Herzogin Anna Amalia Bibliothek	Leopold (1986), 113–18; Dolz (1994), 80–81
127. Celestial (Kassel I, with clockwork), Jost Bürgi	Ca. 1585	M	23	Kassel, Staatliche Kunstsammlungen Kassel	Leopold (1986), 119–25; Mackensen (1982), 131–33
128. Celestial (with clockwork) and terrestrial, Johannes Reinhard and Georg Roll	1586	M	C = 21 T = 10	Dresden, Staatlicher Mathematisch-Physikalischer Salon	King and Millburn (1978), 85; Dolz (1994), 82–85
129. Celestial (part of armillary sphere), Petrus Aspheris	1586	M	14	London, National Maritime Museum	Dekker (1999a), 149–51
130. Celestial, Jacob Floris van Langren and his sons	1586	P	32.5	Linköping, Stifts- och Landesbiblioteket	Van der Krogt (1993), 423–24 and 429
131. Terrestrial globe-cup with a small armillary sphere, Abraham Gessner	1587	M	18	Vienna, Kunsthistorisches Museum, Kunstkammer	Allmayer-Beck (1997), 72 and 335; Lösel (1983), 196n; see also fig. 6.12
132. Terrestrial, Johann Reinhold	1588	M	10	London, National Maritime Museum	Dekker (1999a), 104–5 and 202–3
133. Celestial (with clockwork) and terrestrial, Johann Reinhold and Georg Roll	1588	M	C = 21 T = 10	Paris, Conservatoire National des Arts et Métiers (CNAM)	Duprat (1973), no. 160; *Prag um 1600* (1988), 562
134. Celestial (with clockwork) and terrestrial, Johann Reinhold and Georg Roll	1589	M	C = 21 T = 10	Naples, Osservatorio Astronomico di Capodimonte	Zinner (1967), 493; *Prag um 1600* (1988), 562
135. Terrestrial globe-cup, Lenhart Krug	1589	M	9	Steiermark, private collection	Allmayer-Beck (1997), 341; Kugel (2002), 74–77
136. Terrestrial, Jacob Floris van Langren and his sons	1589	P	32.5	London, National Maritime Museum; Rome, Museo Astronomico e Copernicano	Van der Krogt (1993), 421–22 and 429; Dekker (1999a), 397–99
137. Celestial, Jacob Floris van Langren and his sons	1589	P	32.5	London, National Maritime Museum	Van der Krogt (1993) 423–24 and 429; Dekker (1999a), 399–401
138. Terrestrial, Jacob Floris van Langren and his sons	1589	P	52.5	Amsterdam, Nederlands Scheepsvaartmuseum	Van der Krogt (1993), 430–33

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
139. Terrestrial globe-cup with small armillary sphere on top, Abraham Gessner	Ca. 1590	M	15.5	Basel, Historisches Museum	Stevenson (1921), 1:200; Zinner (1967), 321; Lösel (1983), 197r
140. Terrestrial globe-cup with a small celestial globe on top, Abraham Gessner	Ca. 1590	M	Height 46; diameter unknown	Ribeauvillé (Rappoltsweiler Rathaus, just north of Colmar)	Stevenson (1921), 1:200; Zinner (1967), 321; Lösel (1983) 197q
141. Terrestrial and celestial, attributed to Charles Whitwell	Ca. 1590	M	6.2	London, National Maritime Museum	Dekker (1999a), 101–3 and 203–4
142. Celestial, attributed to Jost Bürgi	Ca. 1590	M	13	Formerly Rothschild Collection	Christie, Manson and Woods (1999), 302–3
143. Cosmographic (part of Ptolemaic sphere by Antonio Santucci)	Ca. 1590	M	Ca. 60	Florence, Istituto e Museo di Storia della Scienza	Miniati (1991), 104; Dekker (2004), 80–84
144. Celestial, anonymous	Ca. 1590	M	72	Kassel, Staatliche Kunstsammlungen Kassel	Mackensen (1982), 135
145. Terrestrial, Emery Molyneux	1592	P	61	Sussex, Petworth House	Wallis (1962); Van der Krogt (1993), 460–63
146. Celestial, Emery Molyneux	1592	P	61	Nuremberg, Germanisches Nationalmuseum; Kassel, Staatliche Kunstsammlungen Kassel	Mackensen (1982), 128; Van der Krogt (1993), 460–63
147. Terrestrial, Antonio Spano	1593	M	8	New York, Pierpont Morgan Library	Yonge (1968), 60 and 61
148. Celestial, Jacob Floris van Langren and his sons	1594	P	32.5	Frankfurt, Historisches Museum	Holbrook (1983), 69–73; Van der Krogt (1993), 424–26 and 429; Glasemann (1999), 15–20
149. Celestial (Kassel II, with clockwork), Jost Bürgi	Ca. 1594	M	23	Kassel, Staatliche Kunstsammlungen Kassel	Leopold (1986), 135–44; Mackensen (1982), 137
150. Celestial (with clockwork), Jost Bürgi	1594	M	14	Zurich, Schweizerisches Landesmuseum	Leopold and Pechstein (1977); Leopold (1986), 176–85
151. Celestial (part of an astronomical clock by Isaac Habrecht [I])	1594	M	Not known	Copenhagen, Rosenborg Slot	Kejlbo (1995), 77–81 and 190
152. Terrestrial (part of an armillary sphere by Ottavio Pisani)	Ca. 1595	M	8.5	Private collection	Kummer (1992), 105
153. Terrestrial globe-cup with a small armillary sphere by Abraham Gessner	Ca. 1595	M	Height, 52; diameter unknown	Plymouth, City Museum and Art Gallery	Lösel (1983), 197s
154. Terrestrial gores, Jodocus Hondius the Elder	Before 1597	P	8	Stuttgart, Württembergische Landesbibliothek	Van der Krogt (1993), 462–63

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
155. Terrestrial, Christoph Schissler and Amos Neuwaldt	1597	M	15	London, National Maritime Museum	Dekker (1999a), 104, 106–7, and 204–6
156. Celestial, Christoph Schissler and Amos Neuwaldt	1597	M	15	Private collection; present whereabouts unknown	Private communication
157. Terrestrial, Jodocus Hondius	1597	P	35	Lucerne, Historisches Museum	Van der Krogt (1993), 464–66 and 472
158. Celestial, Jodocus Hondius	1597	P	35	Lucerne, Historisches Museum	Van der Krogt (1993), 468–70 and 472
159. Celestial gores, Jodocus Hondius	Before 1598	P	8	Stuttgart, Württembergische Landesbibliothek	Van der Krogt (1993), 462–63
160. Terrestrial, Jodocus Hondius	After April 1597	P	35	Strasbourg, Maison de l'Oeuvre Notre-Dame	Van der Krogt (1993), 466 and 471
161. Celestial gores, Willem Jansz. Blaeu	1597	P	34	Cambridge Mass., Harvard University, Houghton Library	Warner (1971); Van der Krogt (1993), 492–93 and 496
162. Terrestrial, Jacob Floris van Langren and his sons	After 1597	P	52.5	Wrocław, Muzeum Archidiecezjalne	Van der Krogt (1993), 433–34
163. Celestial, Carolus Platus	1598	M	23	London, National Maritime Museum	Dekker (1999a), 206–8
164. Terrestrial, Willem Jansz. Blaeu	1599	P	34	Rome, Biblioteca Angelica	Van der Krogt (1993), 488–90 and 495
165. Celestial, Jodocus Hondius	1600	P	35	Amsterdam, Nederlands Scheepvaartmuseum; London, National Maritime Museum	Van der Krogt (1993), 470 and 472; Dekker (1999a), 362–63
166. Terrestrial, Jodocus Hondius	1600	P	35	Salzburg, Carolino Augusteum Salzburger Museum für Kunst und Kulturgeschichte	Van der Krogt (1993), 466 and 471
167. Terrestrial globe-cup with a small celestial globe by Abraham Gessner	Ca. 1600	M	Height, 59.5; diameter unknown	Los Angeles, County Museum of Art	Lösel (1983), 198w
168. Terrestrial globe-cup with a small celestial globe by Abraham Gessner	Ca. 1600	M	Height, 55; diameter 19	Basel, Historisches Museum	Lösel (1983), 198x
169. Terrestrial globe-cup, Christoph Jamnitzer	Ca. 1600	M	13	Amsterdam, Rijksmuseum	Van der Krogt (1984), 159–61
170. Terrestrial globe-cup with a small celestial globe on top, Abraham Gessner	Ca. 1600	M	17	Wolfegg, Schloß Wolfegg	Stevenson (1921), 1:199–200; Zinner (1967), 321; Fauser (1973), 116–19; Lösel (1983), 197v

APPENDIX 6.1 (*continued*)

Globe, author[a]	Date[b]	M/P[c]	Size[d] (cm)	Locations[e]	References[f]
171. Terrestrial globe-cup with a small celestial globe, Abraham Gessner	Ca. 1600	M	T = 17 C = 6	Steiermark, private collection	Allmayer-Beck (1997), 335; Schmidt (1977), 17–18; Kugel (2002), 68–73
172. Terrestrial globe-cup with a small celestial globe on top, Abraham Gessner	Ca. 1600	M	17	Basel, Historisches Museum	Stevenson (1921), 1:200; Zinner (1967), 321; Lösel (1983), 197t
173. Terrestrial globe-cup with a small celestial globe on top, Abraham Gessner	Ca. 1600	M	19	Zurich, Schweizerisches Landesmuseum	Stevenson (1921), 1:200–201; Zinner (1967), 321; Lösel (1983), 198y
174. Terrestrial globe-cup with a small armillary sphere, Abraham Gessner	Ca. 1600	M	Height 49; diameter unknown	Zurich, Schweizerisches Landesmuseum	Zinner (1967), 321; Lösel (1983), 197u
175. Terrestrial gores, Joannes Oterschaden	Ca. 1600	P	17	Amsterdam, Nederlands Scheepvaartmuseum	Van der Krogt (1984), 212–13; Shirley (2001), 252 (no. 237)
176. Terrestrial, Joannes Oterschaden	Ca. 1600	P	17	London, National Maritime Museum	Dekker (1999a), 438–39
177. Celestial, Joannes Oterschaden	Ca. 1600	P	17	London, National Maritime Museum	Dekker (1999a), 439–41
178. Celestial gores, Joannes Oterschaden	Ca. 1600	P	17	Amsterdam, Nederlands Scheepvaartmuseum	Van der Krogt (1984), 213
179. Terrestrial, Christoff Schniepp	Ca. 1600	M	21	BNF	Duprat (1973), no. 187; for the date, see Wawrik (1978), 160–61
180. Terrestrial (Helmstedt), anonymous	Ca. 1600	M	90	Wolfenbüttel, Herzog August Bibliothek	Haase (1972), 57–59 and 71
181. Celestial (Helmstedt), anonymous	Ca. 1600	M	90	Wolfenbüttel, Herzog August Bibliothek	Haase (1972), 57–59 and 71

[a]This list does not include the small (brass) terrestrial globes in armillary spheres, with a few exceptions. For instance, an exception was made for the printed terrestrial spheres made by Caspar Vopel, if only because a good inventory of Vopel's globes is still a desideratum. The entries of Vopel's globes and also those of the gores and globes of François Demongenet included in the list are provisional in anticipation of the definite study of the production of these makers.

[b]Sometimes dates in old inventories have been adapted by recent research, and where possible the publication concerned is included in the entry of the globe.

[c]Manuscript (M) or printed (P).

[d]The diameters of globes quoted in the literature can vary considerably. Therefore, with a few exceptions, values have been rounded off in the list.

[e]As a rule, only one or two locations are provided for printed copies. However, more locations are often given in the quoted literature. For example, the globes of Mercator in the National Maritime Museum are mentioned specifically because this pair has been described in more detail than elsewhere, but the locations of all known globes by Mercator are recorded by Van der Krogt (1993).

[f]For some of the globes there exists a considerable literature, of which only the most recent publications are mentioned in the list. The references for this column are as follows:

Allmayer-Beck, Peter E., ed. 1997. *Modelle der Welt: Erd- und Himmelsgloben.* Vienna: Brandstätter.

Ameisenowa, Zofia. 1959. *The Globe of Martin Bylica of Olkusz and Celestial Maps in the East and in the West.* Trans. Andrzej Potocki. Wrocław: Zakład Narodowy imienia Ossolińskich.

Beyer, Victor, Henri Bach, and Ernest Muller. 1960. "Le globe céleste de Dasypodius." *Bulletin de la Société des Amis de la Cathédrale de Strasbourg,* ser. 2, no. 7, 103–39.

Brink, Claudia, and Wilhelm Hornbostel, eds. 1993. *Pegasus und die Künste.* Munich: Deutscher Kunstverlag.

APPENDIX 6.1 (*continued*)

Calisi, M. 1982. *Il Museo Astronomico e Copernico.* Rome.

Chapiro, Adolphe, Chantal Meslin-Perrier, and Anthony John Turner. 1989. *Catalogue de l'horlogerie et des instruments de précision: Du début du XVI*[e] *au milieu du XVII*[e] *siècle*. Paris.

Christie, Manson and Woods. 1991. *The Murad III Globes: The Property of a Lady, to Be Offered as Lot 139 in a Sale of Valuable Travel and Natural History Books, Atlases, Maps and Important Globes on Wednesday 30 October 1991.* London: Christie, Manson and Woods.

Christie, Manson and Woods. 1999. *Works of Art from the Collection of the Barons Nathaniel and Albert von Rothschild, Thursday 8 July 1999.* London: Christie, Manson and Woods.

Dahl, Edward H., and Jean-François Gauvin. 2000. *Sphæræ Mundi: Early Globes at the Stewart Museum.* [Sillery]: Septentrion; [Montreal]: McGill-Queen's University.

Dekker, Elly. 1995. "Conspicuous Features on Sixteenth Century Celestial Globes." *Der Globusfreund* 43–44, 77–106 (in English and German).

Dekker, Elly (with contributions by Silke Ackermann, Jonathan Betts, Maria Blyzenski, Gloria Clifton, Ann Lean, and Kristen Lippincott). 1999a. *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum.* Oxford: Oxford University Press and the National Maritime Museum.

———. 1999b. "The Globes in Holbein's Painting *The Ambassadors,*" *Der Globusfreund* 47–48, 19–52 (in English and German).

———. 2004. *Catalogue of Orbs, Spheres and Globes.* Florence: Giunti.

Dekker, Elly, and R. van Laere. 1997. *De verbeelde wereld: Globes, atlassen, kaarten en meetinstrumenten uit de 16de en 17de eeuw.* Brussels: Kredietbank.

Dekker, Elly, and Peter van der Krogt. 1993. *Globes from the Western World.* London: Zwemmer.

Del Badia, Jodoco. 1881. "Egnazio Danti: Cosmografo, astronomo e matematico, e le sue opere in Firenze." *La Rassegna Nazionale* 6, 621–31, and 7, 334–74.

Dörflinger, Johannes. 1973. "Der Gemma Frisius-Erdglobus von 1536 in der Österreichischen Nationalbibliothek in Wien," *Der Globusfreund* 21–23, 81–99.

Dolz, Wolfram. 1994. *Erd- und Himmelsgloben: Sammlungskatalog.* Dresden: Staatlicher Mathematisch-Physikalischer Salon.

Duprat, Gabrielle. 1973. "Les globes terrestres et célestes en France." *Der Globusfreund* 21–23, 198–225.

Fauser, Alois. 1964. *Ältere Erd-und Himmelsgloben in Bayern.* Stuttgart: Schuler Verlagsgesellschaft.

———. 1973. *Kulturgeschichte des Globus.* Munich: Schuler Verlagsgesellschaft.

Finsterwalder, Rüdiger. 1998. "Peter Apian als Autor der sogenannten 'Ingolstädter Globusstreifen'?" *Der Globusfreund* 45–46, 177–86.

Fiorini, Matteo. 1899. *Sfere terrestri e celesti di autore italiano, oppure fatte o conservate in Italia.* Rome: La Società Geografica Italiana.

Focus Behaim Globus. 1992. 2 vols. Nuremberg: Germanisches Nationalmuseums.

Glasemann, Reinhard. 1999. *Erde, Sonne, Mond & Sterne: Globen, Sonnenuhren und astronomische Instrumente im Historischen Museum Frankfurt am Main.* Schriften des Historischen Museums Frankfurt am Main, vol. 20. Frankfurt: Waldemar Kramer.

Grenacher, Franz. 1961. "Der sog. St.-Galler Globus im Schweiz. Landesmuseum." *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte* 21, 66–78.

Haase, Yorck Alexander. 1972. *Alte Karten und Globen in der Herzog August Bibliothek Wolfenbüttel.* Wolfenbüttel.

Hartmann, Johannes. 1919. "Die astronomischen Instrumente des Kardinals Nikolaus Cusanus." *Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse,* n.s. 10.

Hess, Jacob. 1967. "On Some Celestial Maps and Globes of the Sixteenth Century." *Journal of the Warburg and Courtauld Institutes* 30, 406–9.

Holbrook, Mary. 1983. "Beschreibung des Himmelsglobus von Henricus, Arnoldus und Jacobus van Langren und eines Planetariums von H. van Laun im Historischen Museum zu Frankfurt am Main." *Der Globusfreund* 31–32, 69–77.

Horn, Werner. 1976. *Die alten Globen der Forschungsbibliothek und des Schloßmuseums Gotha.* Gotha: Forschungsbibliothek.

Kawamura, Hirotada, Kazutaka Unno, and Kazuhiko Miyajima. 1990. "List of Old Globes in Japan." *Der Globusfreund* 38–39, 173–77.

Kejlbo, Ib Rønne. 1995. *Rare Globes: A Cultural-Historical Exposition of Selected Terrestrial and Celestial Globes Made before 1850—Especially Connected with Denmark.* Copenhagen: Munksgaard/Rosinate.

King, Henry C., and John R. Millburn. 1978. *Geared to the Stars: The Evolution of Planetariums, Orreries, and Astronomical Clocks.* Toronto: University of Toronto Press.

Kish, George. 1969–71. "An Early Silver Globe Cup of the XVIth Century." *Der Globusfreund* 18–20, 73–77.

Kratzsch, Konrad. 1984. *Alte Globen.* Weimar: Nationale Forschungs- und Gedenkstätten der Klassischen Deutschen Literatur in Weimar.

Krogt, Peter van der. 1984. *Old Globes in the Netherlands: A Catalogue of Terrestrial and Celestial Globes Made Prior to 1850 and Preserved in Dutch Collections.* Trans. Willie ten Haken. Utrecht: HES.

———. 1985–86. "The Globe-Gores in the Nicolai-Collection (Stuttgart)." *Der Globusfreund* 33–34, 99–116.

———. 1993. *Globi Neerlandici: The Production of Globes in the Low Countries.* Utrecht: HES.

Kugel, Alexis. 2002. *Spheres: The Art of the Celestial Mechanic.* Paris: J. Kugel.

Kummer, Werner. 1980. "Liste alter Globen im Bundesland Hessen und aus einer Sammlung in Ingelheim in Rheinhessen." *Der Globusfreund* 28–29, 67–112.

———. 1983. "Liste alter Globen im Bundesland Hessen und aus einer Sammlung in Ingelheim in Rheinhessen, 2: Teil." *Der Globusfreund* 31–32, 15–68.

———. 1992. "Liste alter Globen im Bundesland Rheinland-Pfalz der Bundesrepublik Deutschland." *Der Globusfreund* 40–41, 89–117.

Lamb, Tom, and Jeremy Collins, eds. 1994. *The World in Your Hands: An Exhibition of Globes and Planetaria from the Collection of Rudolf Schmidt.* Leiden: Museum Boerhaave; London: Christie's.

Leopold, John H. 1986. *Astronomen, Sterne, Geräte: Landgraf Wilhelm IV. und seine sich selbst bewegenden Globen.* Lucerne: J. Fremersdorf.

Leopold, John H., and Klaus Pechstein. 1977. *Der kleine Himmelsglobus 1594 von Jost Bürgi.* Lucerne: Fremersdorf.

Lösel, Eva-Maria. 1983. *Zürcher Goldschmiedekunst: Vom 13. bis zum 19. Jahrhundert.* Zürich: Berichthaus.

Mackensen, Ludolf von. 1982. *Die erste Sternwarte Europas mit ihren Instrumenten und Uhren: 400 Jahre Jost Bürgi in Kassel.* 2d ed. Munich: Callwey.

Manoscritti cartografici e strumenti scientifici nella Bibliotheca Vaticana, secc. XIV–XVII. 1981. Vatican City: Bibliotheca Apostolica Vaticana.

APPENDIX 6.1 (*continued*)

Miniati, Mara, ed. 1991. *Museo di storia della scienza: Catalogo.* Florence: Giunti.

Muris, Oswald, and Gert Saarmann. 1961. *Der Globus im Wandel der Zeiten: Eine Geschichte der Globen.* Berlin: Columbus.

Nagel, Fritz. 1995. "Der Globuspokal." In *Bonifacius Amerbach, 1495–1562: Zum 500. Geburtstag des Basler Juristen und Erben des Erasmus von Rotterdam.* Ed. Holger Jacob-Friesen, Beat R. Jenny, and Christian Müller, 83–86. Basel: Schwabe.

Oberhummer, Eugen. 1926. "Die Brixener Globen von 1522 der Sammlung Hauslab-Liechtenstein." *Akademie der Wissenschaften in Wien, Philosophisch-Historische Klasse, Denkschriften* 67, no. 3.

Oestmann, Günther. 1993(a). *Die astronomische Uhr des Strassburger Münsters: Funktion und Bedeutung eines Kosmos-Modells des 16. Jahrhunderts.* Stuttgart: Verlag für Geschichte der Naturwissenschaften und der Technik.

Oestmann, Günther (with contributions by Elly Dekker and Peter Schiller). 1993b. *Schicksalsdeutung und Astronomie: Der Himmelsglobus des Johannes Stoeffler von 1493.* Exhibition catalog. Stuttgart: Württembergisches Landesmuseum Stuttgart.

Prag um 1600: Kunst und Kultur am Hofe Kaiser Rudolfs II. 1998. 2 vols. Exhibition catalog. Freren: Luca Verlag.

Raemdonck, J. van. 1968. "Les sphères terrestre et céleste de Gérard Mercator." *Annales du Cercle Archéologique du Pays de Waas 5* (1872–75): 259–324. Reprinted in *Les sphères terrestre & céleste de Gérard Mercator, 1541 et 1551: Reproductions anastatiques des fuseaux originaux gravés par Gérard Mercator et conservés à la Bibliothèque royale à Bruxelles.* Preface by Antoine de Smet. Brussels: Editions Culture et Civilisations.

Ravenstein, Ernest George. 1908. *Martin Behaim: His Life and His Globe.* London: George Philip and Son. With a reconstruction of the gores.

Reis, António Estácio dos. 1990. "The Oldest Existing Globe in Portugal." *Der Globusfreund* 38–39, 57–65 (in English and German).

Schmidt, Rudolf. 1977. "Katalog: Erd- und Himmelsgloben, Armillarsphaeren, Tellurien Planetarien." *Der Globusfreund* 24, 1–52.

Schramm, Percy Ernst. 1958. *Sphaira, Globus, Reichsapfel: Wanderung und Wandlung eines Herrschaftszeichens von Caesar bis zu Elisabeth II.* Stuttgart: A. Hiersemann.

Shirley, Rodney W. 2001. *The Mapping of the World: Early Printed World Maps, 1472–1700.* 4th ed. Riverside, Conn.: Early World.

Soly, Hugo, ed. 1999. *Charles V, 1500–1558, and His Time.* Antwerp: Mercatorfonds.

Stevenson, Edward Luther. 1921. *Terrestrial and Celestial Globes: Their History and Construction Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy.* 2 vols. New Haven: Yale University Press.

Wallis, Helen. 1962. "The First English Terrestrial Globe." *Der Globusfreund* 11, 158–59 (in English and German).

Warner, Deborah Jean. 1971. "The Celestial Cartography of Giovanni Antonio Vanosino da Varese." *Journal of the Warburg and Courtauld Institutes* 34, 336–37.

Wawrik, Franz. 1978. "Der Erdglobus des Johannes Oterschaden." *Der Globusfreund* 25–27, 155–67.

Wawrik, Franz, and Helga Hühnel. 1994. "Das Globenmuseum der Österreichischen Nationalbibliothek." *Der Globusfreund* 42, 3–188.

Wolff, Hans. 1989. "Das Münchener Globenpaar." In *Philipp Apian und die Kartographie der Renaissance,* 153–65. Exhibition catalog. Weissenhorn: A. H. Konrad.

Woodward, David. 1987. *The Holzheimer Venetian Globe Gores of the Sixteenth Century.* Madison: Juniper.

Yonge, Ena L. 1968. *A Catalogue of Early Globes Made prior to 1850 and Conserved in the United States: A Preliminary Listing.* New York: American Geographical Society.

Zakrzewska, Maria N. 1965. *Catalogue of Globes in the Jagellonian University Museum.* Trans. Franciszek Buhl. Cracow.

Zinner, Ernst. 1967. *Deutsche und niederländische astronomische Instrumente des 11.–18. Jahrhunderts.* 2d ed. Munich: Beck.