

10 • Map Projections in the Renaissance

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This chapter is organized in four main sections reflecting broad types of maps for which projections were useful in the European Renaissance: world maps (and globes), nautical charts, regional maps, and celestial maps.

PROJECTIONS FOR WORLD MAPS

When we talk of a “world map,” it is important to distinguish between a map of the world as known at the time the map was made (the inhabited world or *oikoumene*) and a map of the whole 360 degrees of longitude and 180 degrees latitude of the earth. One of the themes that emerges in this chapter is how the demand for maps of the whole world, and not just the *oikoumene*, expanded the options for developing map projections. The world map had to be expanded in two directions to accommodate new geographical knowledge on the part of Europeans. The southern hemisphere, the traditional classical location of the antipodes beyond the equatorial Torrid Zone, became known to Portuguese navigators in the fifteenth century. The identity of the western hemisphere, which would eventually become the New World or the Americas, developed in the sixteenth. The map could be expanded in three main ways: by simply doubling the traditional circular representation of a hemisphere; by geometrically projecting the whole world into a single geometric figure, such as a rectangle or an oval; or by splitting the world into a number of small geometric pieces (gores) that could be used to make globes (fig. 10.1). This division is similar to that of Jacques Severt, the author of a rare contemporary general description of map projections. Severt discusses five types of world projections according to their general shape: a polar azimuthal projection he named after Guillaume Postel (see fig. 47.6), a double hemisphere (named after André Thevet), an oval (named after Giacomo Gastaldi), an extended “cordiform” (named after Gemma Frisius), and a rectangular (named after Gerardus Mercator).¹

ONE HEMISPHERE TO TWO

The classical and medieval zonal diagrams usually consist of hemispheres bounded by circles with horizontal

straight parallels usually limited to the equator, the Arctic and Antarctic circles, and the tropics of Cancer and Capricorn. This is the case with a 1493 zone map by

Editor’s note: John Parr Snyder completed his chapters for Volumes 3–6 of the *History of Cartography* so early that he was encouraged to publish them as a separate book, which appeared as *Flattening the Earth: Two Thousand Years of Map Projections* (Chicago: University of Chicago Press, 1993; reprinted with corrections 1997). In the preface to that book, he explains the history of his association with the History of Cartography Project (xvii–xviii).

This chapter complements Snyder’s already published work. Its purpose is not to summarize the original text but to recast it in a more general mode and to add information and references that have appeared since the author’s death in 1997. The structure has been modified according to the main types of map for which the projections were intended rather than following Snyder’s original arrangement according to mathematical typology or developable surface (plane, cone, cylinder). The reader frequently is referred to Snyder’s book for details on the mathematics and for specific bibliographical references on individual projections. The choice of figures is also intended to supplement Snyder’s book; they illustrate the historical maps themselves rather than the modern reconstructions that he used.

Accessible general secondary references to the history of map projections other than Snyder include, in chronological order: M. d’Avezac, “Coup d’oeil historique sur la projection des cartes de géographie,” *Bulletin de la Société de Géographie*, 5th ser., 5 (1863): 257–361 and 438–85, reprinted in *Acta Cartographica* 25 (1977): 21–173; Matteo Fiorini, *Le proiezioni delle carte geografiche*, 1 vol. and atlas (Bologna: Zanichelli, 1881); A. E. Nordenskiöld, *Facsimile-Atlas to the Early History of Cartography with Reproductions of the Most Important Maps Printed in the XV and XVI Centuries*, trans. Johan Adolf Ekelöf and Clements R. Markham (Stockholm: P. A. Norstedt, 1889; reprinted New York: Dover, 1973); Johannes Keuning, “The History of Geographical Map Projections until 1600,” *Imago Mundi* 12 (1955): 1–24; Richard E. Dahlberg, “Evolution of Interrupted Map Projections,” *International Yearbook of Cartography* 2 (1962): 36–54; J. A. Steers, *An Introduction to the Study of Map Projections*, 15th ed. (London: University of London Press, 1970); and Ad Meskens, “Le monde sur une surface plane: Cartographie mathématique à l’époque d’Abraham Ortelius,” in *Abraham Ortelius (1527–1598): Cartographe et humaniste*, by Robert W. Karrow et al. (Turnhout: Brepols, 1998), 70–82.

1. Jacques Severt, *De orbis catoptrici: Sev mapparum mundi principis, descriptione ac usu, libri tres*, 2d ed. (Paris: Lavrentivs Sonnivm, 1598), 97–110; copy in Chicago, Newberry Library, Case folio oGA103.S49 1598. Other works contemporary to our period include Bernhardus Varenius, *Geographia generalis, in qua affectiones generales telluris explicantur* (Amsterdam: L. Elzevirium, 1650), and Louis de Mayerne Turquet [Louis Turquet de Mayerne], *Discours sur sa carte universelle* (Paris, 1648).

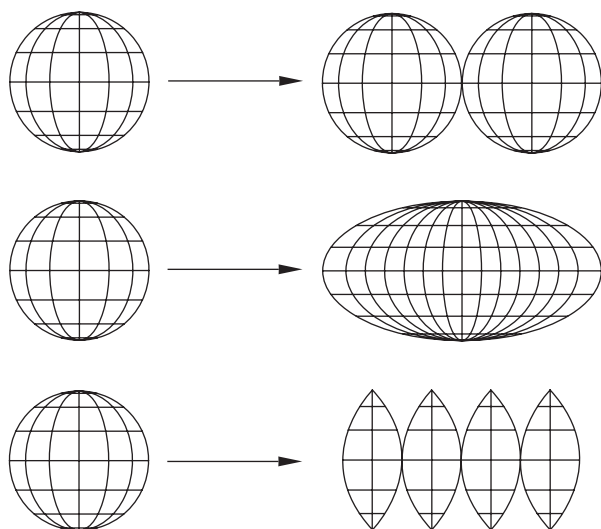


FIG. 10.1. THREE WAYS OF EXPANDING THE WORLD MAP. Before the explorations of the Renaissance, mapmakers had only one hemisphere to represent, the hemisphere in which the *oikoumene* or inhabited world resided. Cartographers interested in projecting the entire globe had basically three choices: (1) making two hemispheres; (2) containing the projection within some geometric shape, such as an oval, rectangle, or cordiform; or (3) splitting the world in various ways to produce globe gores.

Zacharius Lilius. Nearly a century later, the basic zone map design was still being used by Benito Arias Montano in his *Sacrae geographiae tabulam ex antiquissimorum cultor* (1571).²

In the thirteenth century, Roger Bacon described a device for plotting places using longitude and latitude values. A map was made with this device, and although he did not describe the drawing of a graticule for it, the very plotting of the places from an equally divided equator and outer meridian imply a projection. In the sixteenth century, two-hemisphere projections based on this principle appeared, possibly linked to a map introduced by Pierre d'Ailly (Petrus Alliacus), whose interest in Bacon's work has been established.³ An early example was prepared by Franciscus Monachus about 1527 in which the equator was marked equally for degrees of longitude and a bounding circle was marked equidistantly for parallels of latitude (fig. 10.2). A much larger and more elaborate example was the map engraved on circular copperplates published by Michele Tramezzino in 1554.⁴ Severt's archetypal map by André Thevet appears to be Thevet's continental map that appeared in *La cosmographie universelle* (1575).

Similar views of the earth were portrayed in pseudoglobular projections, such as in the map in the German edition of Ptolemy's *Geography* of about 1495 (see fig. 9.8). This map was not, however, the first to "extend the Ptolemaic grid to cover the complete sphere," as Randles suggests.⁵ The map shows only 180 degrees of longitude.

Similar woodcuts of terrestrial globes include images of 1509 (anonymous), 1533 (Johannes Schöner), and 1524 and later editions (Peter Apian).⁶

Projections of a hemisphere that could be extended to two hemispheres covering the whole world also included mathematically rigorous azimuthal projections.⁷ They include the orthographic, perspective, stereographic, and azimuthal equidistant projections. The gnomonic projection was used exclusively for sundials during this period and is discussed later in the section on sundials.

Without precise measurement of the graticule, it is difficult to establish the difference between perspective hemispherical projections centered at a finite distance from earth and the orthographic, the projection center of which is at infinity. For example, the projection of the terrestrial globe constructed for Johannes Stabius by Albrecht Dürer in 1515 (fig. 10.3) has been described as an oblique orthographic.⁸ It is more likely to be a perspective projection, however, because it shows only 150 degrees of longitude along the equator, whereas the orthographic projection would show 180 degrees. Furthermore, the ellipses representing the parallels are not similar figures (as they are in the orthographic projection) but, moving from the north to the south pole, appear progressively less foreshortened because of their varying distances from the horizon line. If we compare Dürer's globe to the orthographic projection that appears as an inset to the world map *Nova totius terrarum orbis descriptio* of 1571 by Gerard de Jode or the hemispheres of 1597 drawn by Fausto Rughesi (fig. 10.4), we find very different results.⁹

Although the earliest use of the stereographic projection was for the star maps on astrolabes (see the section on celestial maps that follows), polar, equatorial, and

2. Snyder, *Flattening the Earth*, 15–16.

3. David Woodward with Herbert M. Howe, "Roger Bacon on Geography and Cartography," in *Roger Bacon and the Sciences: Commemorative Essays*, ed. Jeremiah Hackett (Leiden: E. J. Brill, 1997), 199–222.

4. Rodney W. Shirley, *The Mapping of the World: Early Printed World Maps, 1472–1700*, 4th ed. (Riverside, Conn.: Early World, 2001), 61 (no. 57) and 109–11 (no. 98).

5. W. G. L. Randles, "Classical Models of World Geography and Their Transformation Following the Discovery of America," in *The Classical Tradition and the Americas*, ed. Wolfgang Haase and Meyer Reinhold, vol. 1, *European Images of the Americas and the Classical Tradition*, 2 pts. (Berlin: W. de Gruyter, 1994), pt. 1, 5–76, esp. 36.

6. *Globus mundi* (Strasbourg, 1509), title page; Johannes Schöner, *Opusculum geographicum* (Nuremberg, 1553), title page; Peter Apian, *Cosmographicus liber* (Landshtut, 1524), title page and fol. 1v; and see Snyder, *Flattening the Earth*, 289 n. 44.

7. Snyder, *Flattening the Earth*, 16–29.

8. Snyder, *Flattening the Earth*, 17–18.

9. Filippo Camerota, personal e-mail to David Woodward, 2 January 2001. For the maps, see Shirley, *Mapping of the World*, 146–47 (no. 124) and 224–25 (no. 206).



FIG. 10.2. DOUBLE HEMISPHERE MAP BY FRANCISCUS MONACHUS, CA. 1527. In these images, taken from the title page and first page of *De orbis situ*, Monachus centered the Old World in the Indian Ocean in order to include Africa and Asia in this simple projection in which meridians are spaced equally along the equator. The hemisphere containing the New World shows South America as a separate continent, but North America is joined to Asia. Diameter of each hemisphere: 6.5 cm. Photograph courtesy of the John Carter Brown Library at Brown University, Providence (F529.F819d).

oblique cases were all used for terrestrial maps in the sixteenth century.¹⁰ On the polar aspect, the meridians are straight lines and the parallels are concentric circles, the spacing of which increases away from the pole. In 1507, Walter Lud of St. Dié prepared the earliest existing world map based on the polar stereographic.¹¹ Gregor Reisch (1512) and Peter Apian (1524) also used the polar aspect. In 1596 John Blagrave used the north polar stereographic to the equator but appended the southern hemisphere in four sections according to an uncertain projection, neither conformal nor azimuthal, which placed the world in a square (fig. 10.5).¹²

The oblique stereographic was recommended for geographical maps as an original projection by Stabius and promoted as the fourth of four new projections by Johannes Werner in his 1514 revision and translation into Latin of part of Ptolemy's *Geography*.¹³ In spite of this interest, the oblique stereographic was seldom used for maps during the sixteenth century, although Jacques de Vaulx produced an unusual example in a manuscript atlas of 1583 for a pair of hemispheres centered on Paris and its opposite point.¹⁴

The equatorial stereographic apparently did not appear as a world map until 1542 in the manuscript "Boke of Idrography" by Jean Rotz.¹⁵ But it was the two-hemisphere world map of 1587 by Rumoldus Mercator that launched what was to become the most common projection for the eastern and western hemispheres in the seventeenth century (fig. 10.6). In the so-called Drake map, published about 1595, Jodocus Hondius shifted the central meridians 90 degrees so that Europe, Africa, and the Americas could appear in one hemisphere, thereby showing the circumnavigational routes of Francis Drake and Thomas Cavendish to better advantage (fig. 10.7). Philip Ekebrecht prepared a map in 1630 for Johannes Kepler's astronomical use, with one hemisphere split down the central meridian and the halves placed on either side of the intact hemisphere, which was centered on Europe and Africa (fig. 10.8).¹⁶

The azimuthal equidistant projection made its debut on an incomplete and rudimentary star map of 1426 by

10. Snyder, *Flattening the Earth*, 20–28.

11. Walter Lud (Gualterius Ludd), *Speculi orbis succintissima sed neque poenitenda, neque inelegans declaratio et canon* (Strasbourg: Johannes Grüninger, 1507), referenced in Keuning, "Geographical Map Projections," 7–8.

12. Snyder, *Flattening the Earth*, 22–23, and Shirley, *Mapping of the World*, 212–13 (no. 191).

13. Claudius Ptolemy, *Noua translatio primi libri Geographiæ . . .*, ed. and trans. Johannes Werner, in *In hoc opere haec continentur*, by Johannes Werner (Nuremberg, 1514), containing *Libellus de quatuor terrarum orbis in plano figurationibus*.

14. BNF, MS. Franç. 159, fols. 27r and v.

15. BL, Royal MS. 20 E IX.

16. Shirley, *Mapping of the World*, 178–79 (no. 157), 208–9 (no. 188), and 358–59 (no. 335).



FIG. 10.3. PERSPECTIVE PROJECTION BY DÜRER AND STABIUS, 1515. This projection of the Old World, using a modified Ptolemaic representation (but without a closed Indian Ocean) has often been described as an oblique orthographic, but the inclusion of only 150 degrees of longitude

along the equator (rather than the 180 degrees required by an orthographic) disproves this.

Size of the original: 63.7 × 85 cm. Photograph © copyright the Trustees of the British Museum, London (1848-11-11-8).

Conrad of Dyffenbach and had appeared several times by the mid-sixteenth century, including in a map by Dürer of about 1515.¹⁷ The polar form consists simply of equally spaced latitude circles centered about the pole with radiating straight meridians. This projection was used for two terrestrial hemispheres by Henricus Glareanus about 1510 and by several others between 1511 and 1524, including Giovanni Vespucci, who in 1524 showed the southern hemisphere split into two semicircular halves placed tangent to the northern hemisphere (fig. 10.9). Apparently the first to prepare a north polar azimuthal equidistant map of the entire world was Louis de Mayerne Turquet in 1648, who also explained it and other projections in a manual of mapmaking.¹⁸ The world map on the floor of the Paris Observatory was drawn on it in the 1680s.

FROM THE *OIKOUMENE* TO A SINGLE GEOMETRIC FIGURE CONTAINING THE WHOLE WORLD

In his second-century A.D. *Geography*, Claudius Ptolemy introduced two conic-like projections for maps of the *oikoumene* of Greco-Roman times that covered just over a quarter of the earth's surface.¹⁹ The first projection, with meridians represented as straight lines broken at the equator and parallels of latitude represented as concen-

17. Snyder, *Flattening the Earth*, 29–30.

18. Mayerne Turquet, *Discours sur la carte universelle*, and Shirley, *Mapping of the World*, 397–98 (no. 375); for Vespucci, see 58–59 (no. 54).

19. Snyder, *Flattening the Earth*, 10–14, and O. A. W. Dilke and eds., "The Culmination of Greek Cartography in Ptolemy," in *HC* 1:177–200, esp. 185–88.

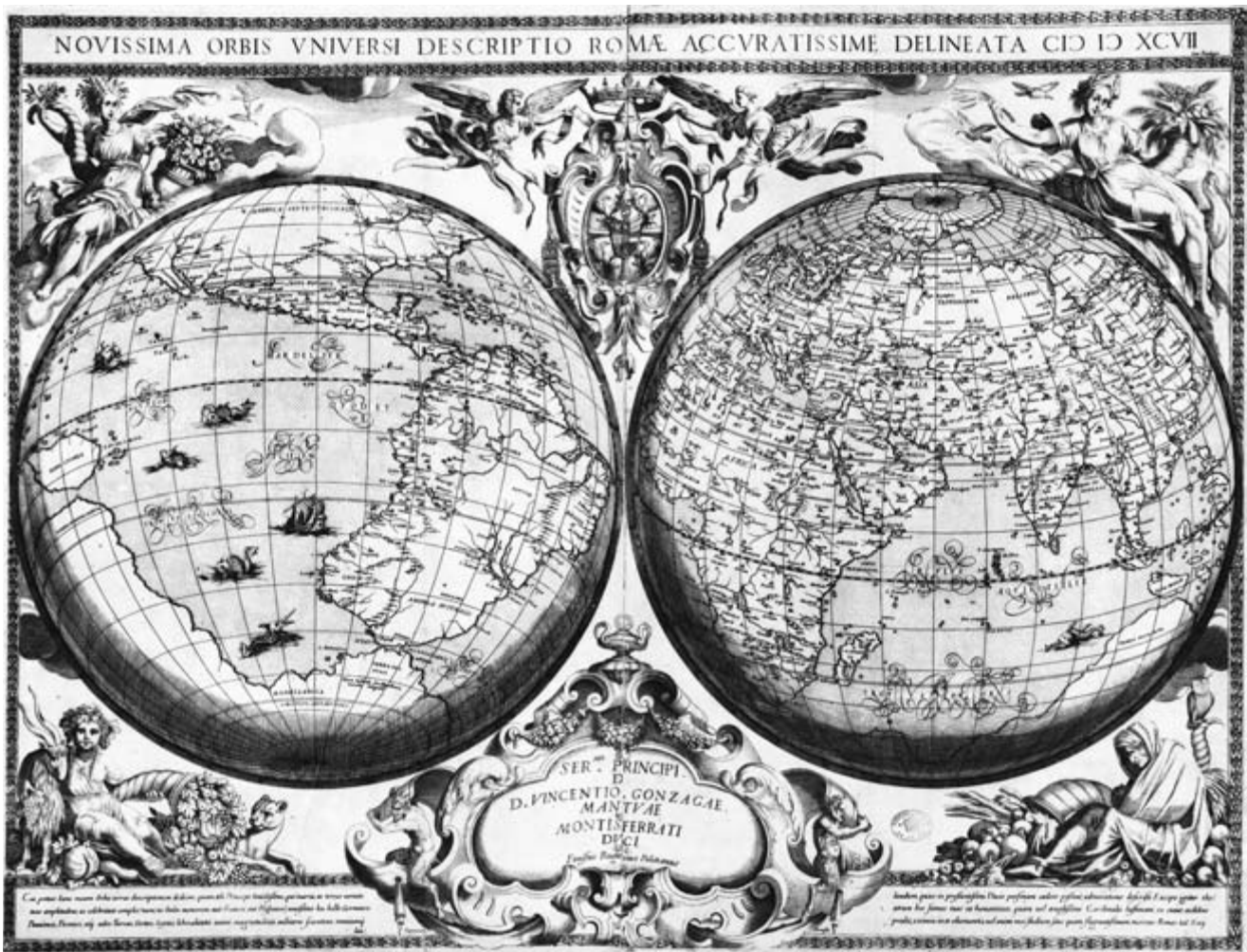


FIG. 10.4. OBLIQUE ORTHOGRAPHIC PROJECTION BY FAUSTO RUGHESI, 1597. Titled *Novissima orbis universi descriptio Romæ accuratissime delineata*, this elegant construction neatly highlights the northern hemisphere on the right

side and the southern hemisphere on the left, thus emphasizing areas of the world that had been better known.

Size of the original: ca. 52.8 × 70 cm. Photograph courtesy of the BL (Maps 184.i.1[1]).

tric, circular arcs, was used in several early manuscripts of the *Geography* and in the first printed edition with maps (Bologna, 1477). Ptolemy's second projection, the one he preferred, has concentric, equidistant, circular arcs for parallels, but curved rather than straight meridians. The northern, southern, and middle parallels of the *oikoumene* (about 63°N, 16°25'S, and 23°50'N, respectively) are marked off correctly for meridians up to 90 degrees on each side of the central meridian. Meridians with circular arcs were drawn through these three points. Nicolaus Germanus first used it in his manuscripts of Ptolemy's *Geography* dating from about 1470.

Ptolemy's projections were modified in the late fifteenth century to accommodate European geographical discoveries beyond the *oikoumene*, but they still did not cover the whole earth.²⁰ Giovanni Matteo Contarini's 1506 map modified Ptolemy's first projection in three ways: it

doubled the span of meridians from 180 degrees to the full 360 degrees; it extended latitudes to the north pole (shown as a circular arc); and it continued the meridians unbroken to about 35°S without a bend at the equator.²¹

Ptolemy's second projection was modified for Henricus Martellus Germanus's map of about 1490. The map shows all 360 degrees of longitude. The parallels extend, however, from the north pole to 40°S instead of from about 63°N to 16°S on Ptolemy's projection. Martin Waldseemüller's 1507 map is on a similar projection, except that the breaks at the equator are much more abrupt than on the Martellus map, a difference that Keuning ascribes to practical limitations in the sizes of the wood-

20. Snyder, *Flattening the Earth*, 29–38.

21. Shirley, *Mapping of the World*, 23–25 (no. 24).

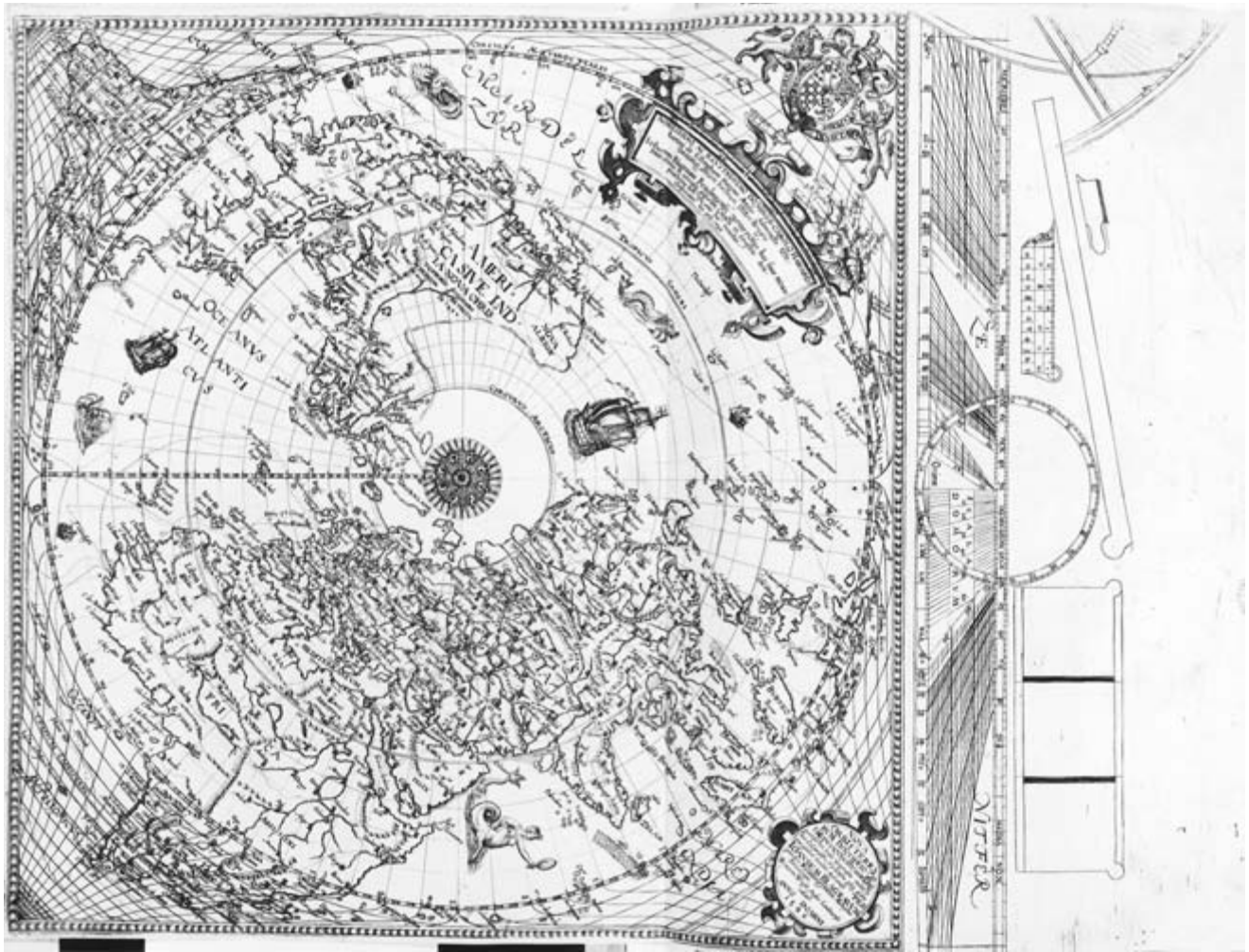


FIG. 10.5. POLAR STEREOGRAPHIC PROJECTION WITH EXTENSIONS TO A SQUARE, BY JOHN BLAGRAVE, 1596. This unusual projection was designed as a mathematical instrument, as is evident from the scales and rotating point-

ers, which were intended to be cut out.

Size of the original: ca. 26.5 × 26.5 cm (map). Photograph courtesy of the BL (Harl. 5935[15]).

blocks used.²² Bernardo Silvano's map in the 1511 edition of Ptolemy's *Geography* extended the meridians of Ptolemy's projection to 320 degrees of the globe and markedly decreased the radii of the latitude circles to place their center about 10 degrees above the north pole.

Although Ptolemy was concerned only with mapping the *oikoumene*, his scheme of describing the position of places by their longitude and latitude could theoretically be applied to the whole sphere. The potential of a system of spatial reference by which every point on earth could be plotted on a map on which every potential route for exploration could be shown might seem attractive. It is a geographical idea of elegant simplicity. But maps extending this principle to representations of the whole world were slower to appear than we might think.

About 1500, Johannes Stabius, a professor of mathematics in Vienna, invented a series of three heart-shaped (cordiform) projections publicized by Johannes Werner of

Nuremberg in 1514. All three were mathematically of equal area (unlike Ptolemy's projections) and were developed into several influential maps that are discussed later. The first Werner-Stabius projection was apparently not used, while the third was apparently first employed by Oronce Fine for a world map in 1534/36 (see plate 57) that was copied by Giovanni Paolo Cimerlini in 1566.²³

The second Werner (or Stabius-Werner) projection first appeared on a world map by Apian (Ingolstadt, 1530). It is the only one of the Stabius-Werner projections that shows the whole world. It was modified in 1531 by Fine to produce a double cordiform world map. Separate northern and southern hemispheres were drawn accord-

22. Keuning, "Geographical Map Projections," 11, and see figure 9.9 in this volume.

23. Snyder, *Flattening the Earth*, 33–38, and Shirley, *Mapping of the World*, 77 (no. 69) and 135 (no. 116).



FIG. 10.6. DOUBLE HEMISPHERE STEREOGRAPHIC PROJECTION BY RUMOLDUS MERCATOR, 1587. Although not the earliest example of such projection, which had previously appeared in manuscript, Rumoldus Mercator's printed map set a fashion for world maps, making the double

hemisphere stereographic the most common projection for world maps in the seventeenth century.

Size of the original: ca. 28.5 × 51.9 cm (map). Photograph courtesy of the BL (Maps C.3.c.4).

ing to the Werner projection and centered about the respective poles; the two circular arcs representing the equator were made tangent at the central meridian. After other editions, Fine's double cordiform projection was used by Mercator for his world map of 1538.²⁴ There was occasional later use, such as in the 1592 map of the northern hemisphere by Christian Sgrooten, but the cordiform projections all but disappeared by the eighteenth century in favor of Rigobert Bonne's projection, which was a more general adaptation of Werner's projection that provided for less angular distortion in a map of a continent.

In 1556, the Norman navigator Guillaume Le Testu showed cartographic versatility by using six different projections in a manuscript sea atlas. The types of projection used include Fine's octant (projection of an eighth of a globe), Apian's globular, an Apianlike oval, another modified Werner, a rudimentary attempt at an oblique perspective, and a four-lobed star. The last projection, in which petal lobes bounded by circular arcs of meridians 90 degrees apart were joined at the north pole, was among the first of a general style that has repeatedly been used up to the present in different forms.²⁵

The oval type of projection resembles a worldwide version of some of the globular hemispheres.²⁶ It was produced with several variations. Common to nearly all oval projections are equidistant horizontal lines for parallels

and curved meridians equidistant at the equator. The first map on which the oval projection was extended to the whole world (globes excepted) was the small oval map made about 1508 by Francesco Rosselli, a commercial printmaker in Florence. This small world map has an importance extending far beyond its modest appearance. Graduated with 360 degrees of longitude and 180 degrees of latitude, it is thus the earliest extant map of the world in the modern sense of "map" and "world." The equator and central meridian are both evenly divided in this 10 degree graticule, and the ratio of their lengths is very close to 2:1. Rosselli's meridians are near-ellipses or ovals connected at the poles and cutting each parallel approximately equidistantly (see plate 16).²⁷ *Typus orbis terrarum*, the world map in Abraham Ortelius's *Theatrum orbis terrarum* (1570), is probably the best-known ex-

24. Shirley, *Mapping of the World*, 68–69 (no. 63), 72–73 (no. 66), and 83–84 (no. 74). See figures 42.14 and 47.2 in this volume.

25. Keuning, "Geographical Map Projections," 23–24, and Snyder, *Flattening the Earth*, 40.

26. Snyder, *Flattening the Earth*, 38–40.

27. David Woodward, "Starting with the Map: The Rosselli Map of the World, ca. 1508," in *Plantejaments i objectius d'una història universal de la cartografia = Approaches and Challenges in a Worldwide History of Cartography* (Barcelona: Institut Cartogràfic de Catalunya, 2001), 71–90.



FIG. 10.7. DOUBLE HEMISPHERE STEREOGRAPHIC PROJECTION BY JODOCUS HONDIUS, CA. 1595. The hemispheres on Hondius's world map showing Drake's and Cavendish's voyages are unusually centered. Abandoning the traditional division between the Old World and the New (see

fig. 10.6), Hondius put South America and Africa in the same hemisphere, probably to avoid splitting the Atlantic. Size of the original: ca. 38 × 53.5 cm. Photograph courtesy of the BL (M.T.6.a.2).

ample of an oval projection (see fig. 44.9), but the projection is nearly identical to the one that Battista Agnese used on several maps of about 1540.²⁸

The last of the major new projections of the whole earth during the period was the sinusoidal, named for its meridians drawn as sine curves. It combines some important qualities with simple construction: areas are shown correctly, and the scale along the central meridian and along every parallel of latitude is correct. The projection is, in effect, an equatorially centered modification of the pole-centered Werner projection.

The origin of this projection has been variously reported. Jean Cossin used it for a world map in 1570 (plate 12), and Hondius used it for maps of South America and Africa in some of his editions of Mercator's atlases of 1606–9. The latter use is probably the basis for one of its names, the Mercator equal-area projection. Nicolas Sanson d'Abbeville used it beginning about 1650 for maps of several continents, while John Flamsteed, the first as-

tronomer royal of England, used it—perhaps curiously, considering its nonconformality—for star charts, resulting in the common name Sanson-Flamsteed.²⁹

GLOBE GORES

The earliest extant globe is Martin Behaim's globe of 1492, although we have references to earlier examples.³⁰ These fifteenth-century globes were painted directly on

28. Meskens, "Le monde sur une surface plane," 81–82.

29. Snyder, *Flattening the Earth*, 49–51.

30. The issue of "the earliest terrestrial globe" is fraught with the usual caveats of "famous firsts," and is thus more complicated than it would appear. To begin with, there were references to terrestrial globes in the classical period, such as Strabo's description of the large globe made for Crates of Mallos and Ptolemy's allusion to globes in the *Geography*. Martin Behaim's globe is justly celebrated as the earliest extant terrestrial globe, an assertion that has yet to be challenged. But late

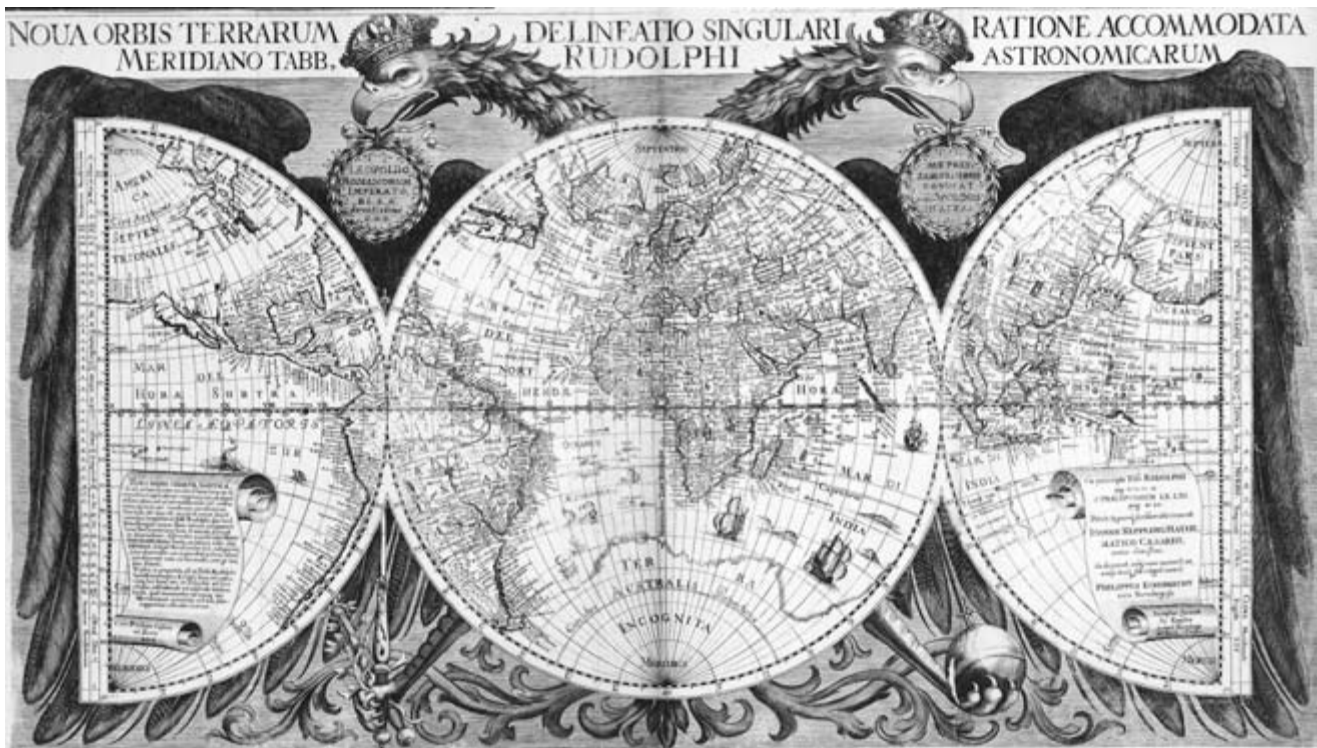


FIG. 10.8. DOUBLE HEMISPHERE STEREOGRAPHIC PROJECTION BY PHILIP ECHEBRECHT, 1630. Eckebrecht's variation on the double hemisphere projection on this map, which shows positions of places derived from Johannes Kepler's Rudophine Tables, was intended to preserve the in-

tegrity of the European and African continents as well as the Atlantic, while splitting the Pacific Ocean.

Size of the original: 38.5 × 68 cm. Photograph courtesy of the BL (48.f.7).

the spherical surface, so no projection was required. From the early sixteenth century, however, printed globes were usually made by pasting strips, known as gores, on a ball. These gores, which could be of various thicknesses and could extend from pole to pole or pole to equator along meridians usually 10 degrees to 30 degrees apart, were a type of map projection. The earliest extant set seems to be those Martin Waldseemüller prepared for a small globe in 1507 consisting of twelve gores 30 degrees wide with a 10 degree graticule.³¹ Some other gore maps are joined at the poles instead of the equator, such as mid-sixteenth century sets of gores 10 degrees wide in the northern and southern hemispheres, which appear on a 1542 manuscript map by Alonso de Santa Cruz and a 1555 engraved map by Antonio Floriano.³²

Other gore arrangements represent more interrupted map projections. A manuscript map in the style of Francesco Ghisolfi (ca. 1550) has a central gore of 120 degrees covering Africa and Europe, flanked by two pairs of gores of 60 degrees for the rest of the world.³³ Another map, by Georg Braun (1574), was drawn in the shape of the Habsburg double eagle, with Africa, Europe, and much of Asia in an unbroken section of the projection and the Americas and East Asia literally in the wings (fig. 10.10).³⁴

From time to time, cartographers have also been intrigued by the concept of projecting the globe onto a poly-

medieval references to nonextant terrestrial globes also need to be taken into account. Nicolaus Germanus made a pair of globes for the Vatican library in 1477, as described by Józef Babicz in "The Celestial and Terrestrial Globes of the Vatican Library, Dating from 1477, and Their Maker Donnus Nicolaus Germanus (ca 1420–ca 1490)," *Der Globusfreund* 35–37 (1987–89): 155–68. Earlier nonclassical reports include the globe made by Guillaume Hobit for Philip the Good, duke of Burgundy, between 1440 and 1444, but a manuscript in the BNF describes the construction by Jean Fusoris of an earlier globe (1432) to show the principle of longitude (see chapter 9 in this volume, note 142). Another less clear allusion is to a treatise called "Regionum sive civitatum distantiae," which is described by Johannes Schöner, whose original version may date back to 1430–35 (see p. 139), but the basis for this dating is in doubt. The primacy of the Fusoris and "Regionum" allusions still needs to be established.

31. Figure 6.5 and Shirley, *Mapping of the World*, 28–29 (no. 26). A method for constructing such gores was described by Henricus Glareanus in his manual of geography, *D. Henrici Glareani poetae laureati De geographia liber vnus* (Basel, 1527). See Nordenskiöld, *Facsimile-Atlas*, 71–75, esp. 74.

32. The Santa Cruz map is reproduced in Leo Bagrow, *History of Cartography*, 2d ed., rev. and enl. R. A. Skelton, trans. D. L. Paisey (Chicago: Precedent, 1985), pl. 65. The Floriano map is reproduced in Shirley, *Mapping of the World*, 113 (no. 99).

33. Dahlberg, "Interrupted Map Projections," fig. 2.

34. Shirley, *Mapping of the World*, 154–55 (no. 130).

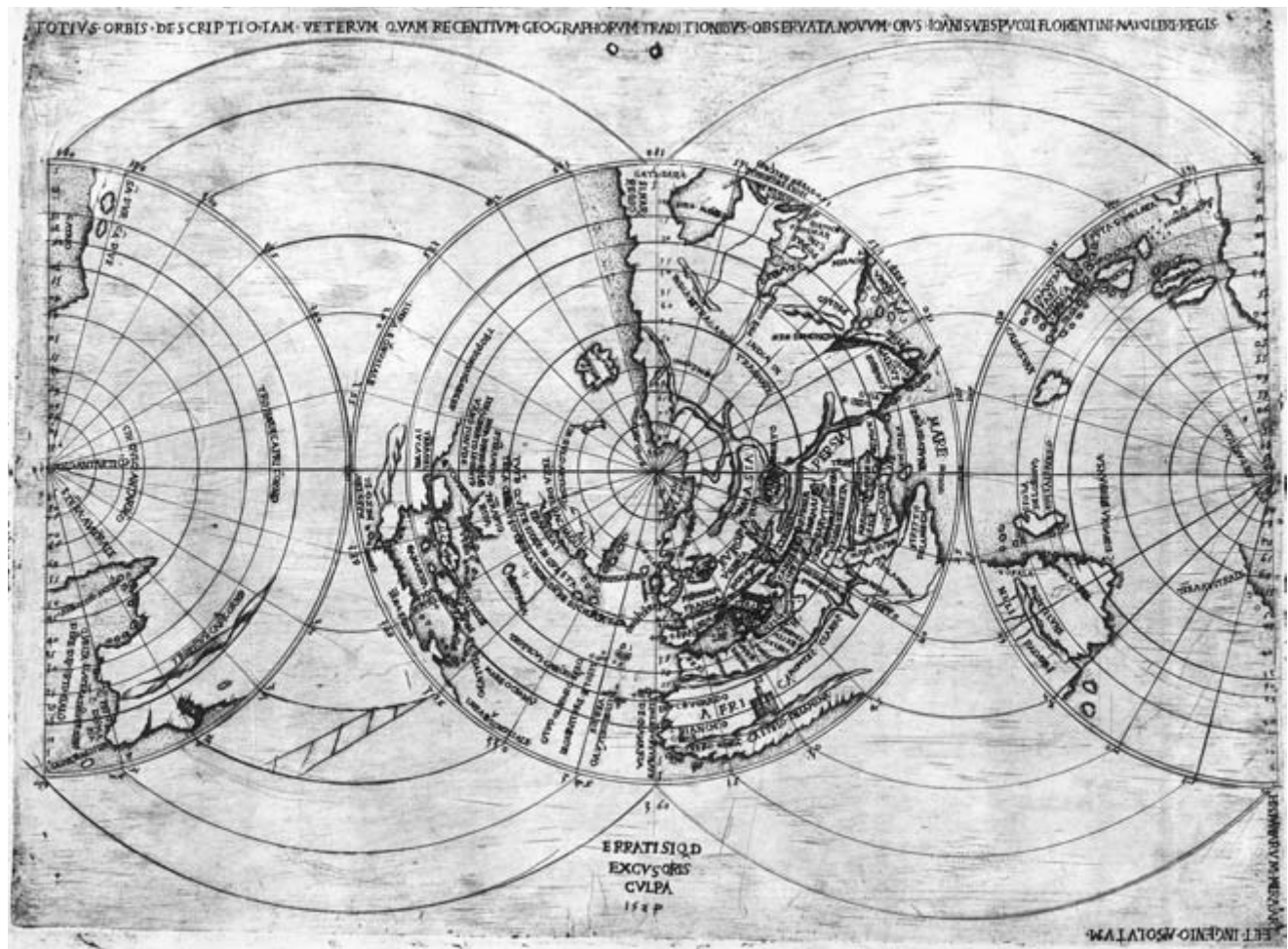


FIG. 10.9. AZIMUTHAL EQUIDISTANT PROJECTION CENTERED ON THE NORTH AND SOUTH POLES BY GIOVANNI VESPUCCI, 1524. The arrangement of the hemispheres in this projection is similar in concept to Eckebreht's, except that the aspect is polar, not equatorial, and the projection is equidistant, not stereographic. Because the map was

produced in association with the Badajoz-Elvas Conference, its purpose was presumably to allow the visualization of the Spanish and Portuguese realms in both eastern and western hemispheres.

Size of the original: 27.5 × 37.5 cm. By permission of Houghton Library, Harvard University (51-2573 PF).

hedron as a compromise between a flat sheet and the round globe. Dürer proposed projecting onto a regular tetrahedron (four triangles), dodecahedron (twelve pentagons), icosahedron (twenty triangles), and other solids. He included diagrams in a book published in 1538 but apparently did not construct maps based on them.³⁵

The surface of the globe may also be conveniently divided into eight equilateral spherical triangles, or octants, each section bounded by the equator and two meridians 90 degrees apart. One such set of octant gores has been controversially attributed to Leonardo da Vinci. Although he may have sketched out ideas for such a projection, as the suggestive page from the Codex Atlanticus shows (fig. 10.11), the drawing in the world map of 1514 does not appear to be in Leonardo's style.³⁶ Later sixteenth-century versions occur in Oronce Fine's *Sphaera*

mundi (Paris, 1551), in which he added meridians and parallels as equidistant, circular arcs within each octant; in one of the 1556 maps by Le Testu; and in a 1616 map by Daniel Angelocrator.³⁷

PROJECTIONS FOR SEA CHARTS

Although the sea charts of the Mediterranean that began to be made in the thirteenth century normally have no

35. Albrecht Dürer, *Underweysung [sic] der Messung, mit dem Zirkel vnd Richtscheyt, in Linien Ebenen vñ gantzen Corporen* (Nuremberg: Hieronymum Andreae, 1538).

36. As Nordenskiöld correctly pointed out in *Facsimile-Atlas*, 76–77, it appears to be more in the style of a clerk or copyist.

37. Snyder, *Flattening the Earth*, 40.

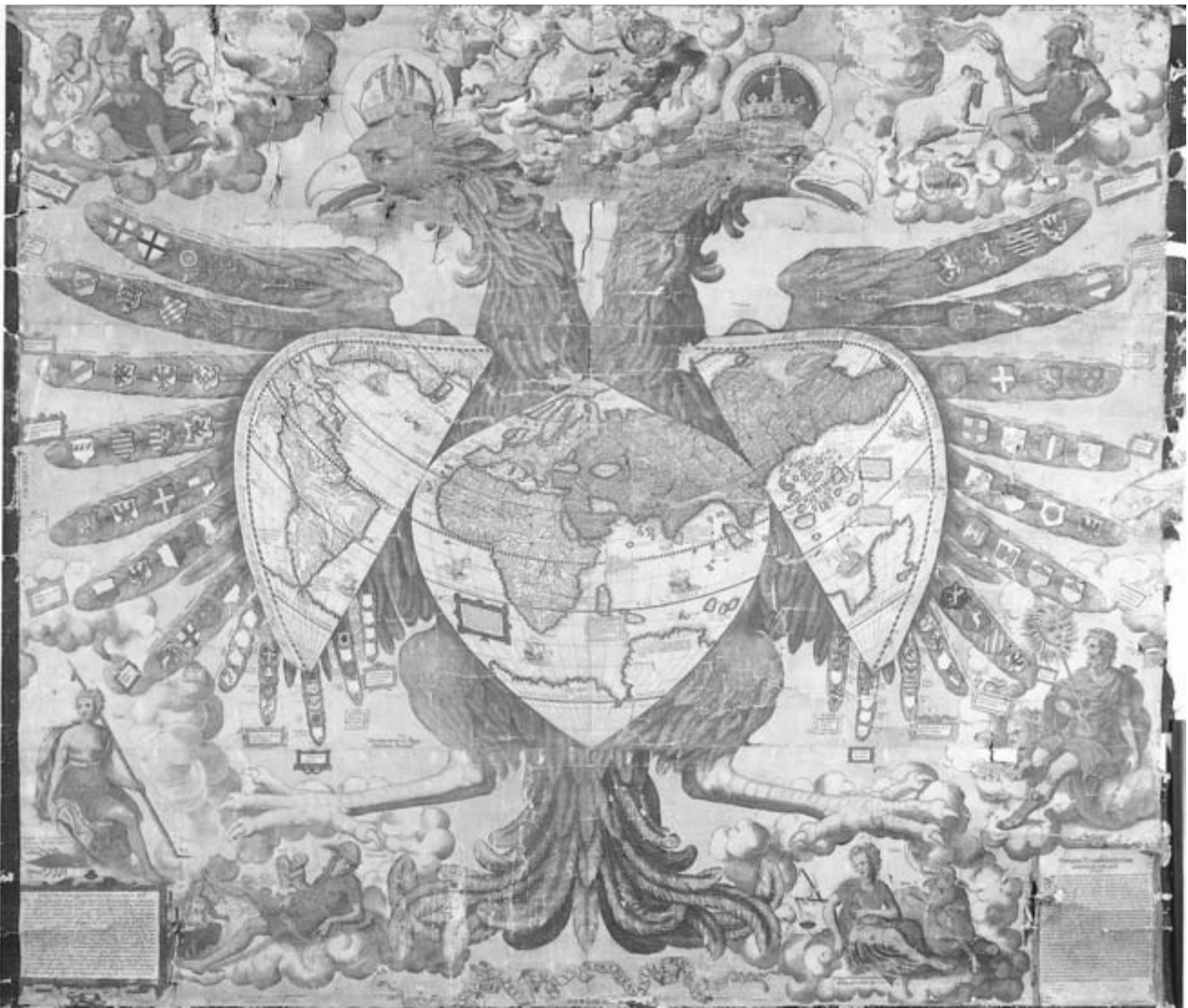


FIG. 10.10. INTERRUPTED CORDIFORM MAP OF THE WORLD BY GEORG BRAUN, 1574. The concept of interrupting a map projection to preserve the representation of shape and area on the globe is similar to the concept of globe gores, but here it has been ingeniously manipulated to con-

form to the shape of the Habsburg double eagle.

Size of the original: 86 × 100 cm. Photograph courtesy of the Herzog August Bibliothek, Wolfenbüttel (Kartensammlung K 2.6).

graticule, graduations of longitude and latitude along the equator and some meridians on early sixteenth-century charts suggest the equirectangular projection. Their almost universally uniform spacing, as on the world charts of 1529 by Diogo Ribeiro, indicates the preeminence of this projection for sixteenth-century nautical charts until Mercator's projection became more widely accepted many years after it was presented in 1569.³⁸

The plane chart is the simplest way of representing the whole world on a projection, depicting it as a rectangle 360 degrees wide and 180 degrees high graduated in squares or rectangles. It was credited by Ptolemy to Marinus of Tyre around 100 A.D., but Ptolemy recommended

using this projection only for maps of smaller areas because of its large degree of deformation in higher latitudes (discussed later). The plane chart represented one of two entirely different world map traditions in the sixteenth century. A map compiled in this tradition was called either a *carta da navigare* or a *carta marina*. It could be easily recognized by the superimposition of a compass rose and radiating lines. The other kind of world map—called a *cosmographia*, *descriptio*, or *tabula*, was intended for

38. Ribeiro's charts are illustrated in figures 30.29 and 30.30; Mercator's chart is figure 10.12; and see also Snyder, *Flattening the Earth*, 5–8.

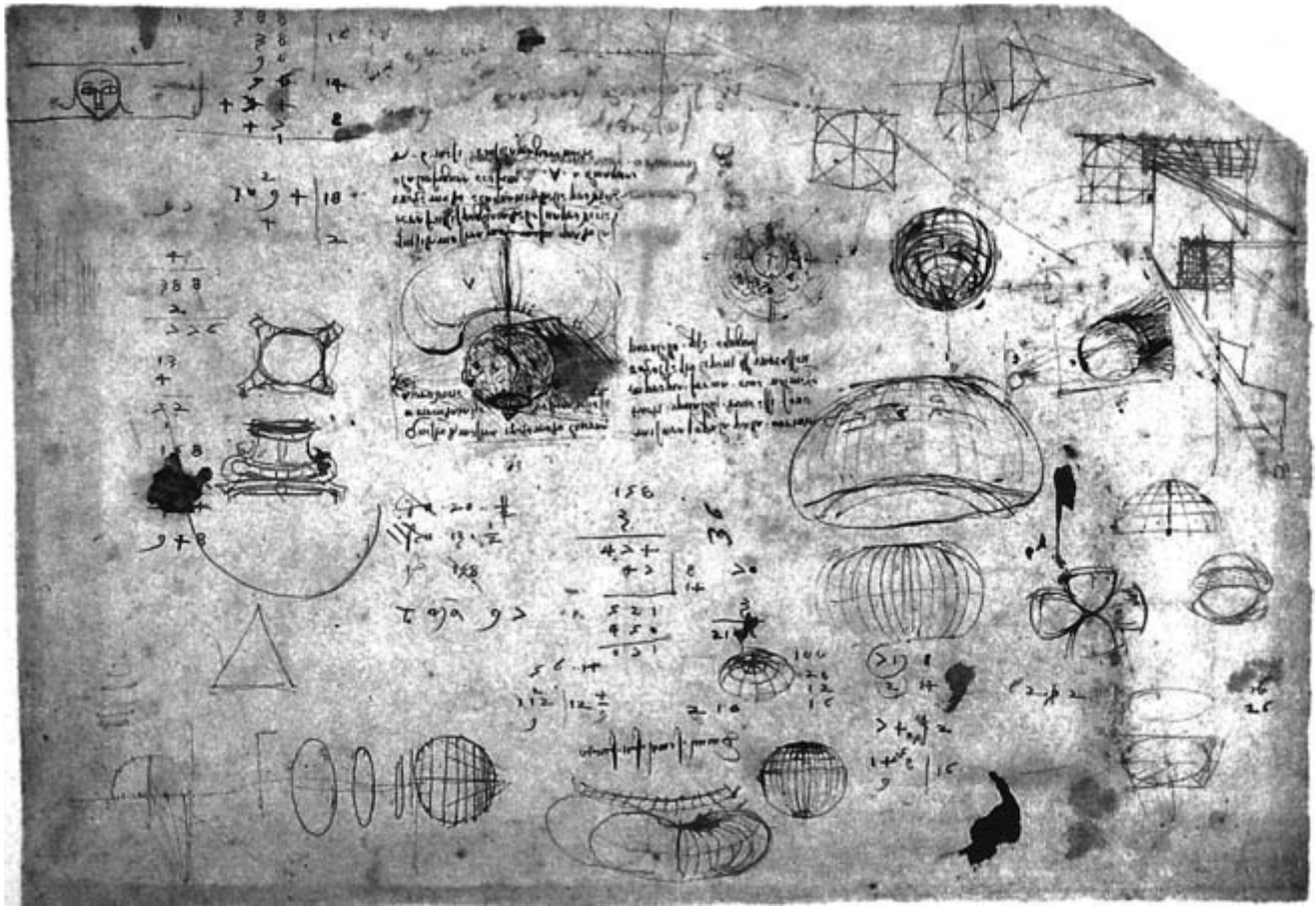


FIG. 10.11. GEOGRAPHIC SKETCHES BY LEONARDO DA VINCI. This page from the Codex Atlanticus demonstrates Leonardo's experimentation with the representation of globe gores, the stereographic projection, an orthographic or perspective projection, and extensions of Ptolemy's second pro-

jection, but the annotations next to the latter surprisingly describe the Ptolemaic geographic content of the map and not its mathematics.

Size of the original: 20.2 × 28.9 cm. Photograph courtesy of the Biblioteca Ambrosiana, Milan (Codex Atlanticus, fol. 521r).

scholarly or educational use. The distinction between the two was explicitly recognized, and the maps often came in pairs.

Although the large manuscript maps of the world drawn in the early sixteenth century (by Alberto Cantino, Nicolò de Caverio, etc.) have no graduations in longitude or latitude (see appendix 30.1), Martin Waldseemüller's 1516 *Carta marina*, which used these charts as a model, was graduated in squares. The term "planisphere" has often been used to describe these large nautical charts, but this usage is misleading. If the root meaning of the word (a flat sphere) is examined, the term could be applied to all map projections that attempt to represent a spherical surface on a plane. Ptolemy originally used the term *planisphaerium* to describe the stereographic projection until François de Aguilón named it the stereographic in 1613.³⁹

Unquestionably, the most famous projection originating in the Renaissance (and since) has been the one simply named for the inventor Gerardus Mercator.⁴⁰ It was

presented in his 1569 world map of eighteen sheets, which was mounted in twenty-one sections totaling about 1.3 by 2 meters in size (fig. 10.12). Like the equirectangular projection, it has equidistant, straight meridians, with parallels of latitude that are straight, parallel, and perpendicular to the meridians. Unlike the equirectangular, it has parallels that are spaced directly proportional to the increasing scale along the parallels. Mercator probably determined the spacing graphically, because tables of secants had not been invented.

Mercator's stated purpose in developing this projection was to provide an aid for navigators. All lines of constant bearing (loxodromes or rhumb lines) are straight lines. The projection thus became valuable to sailors, who

39. François de Aguilón, *Opticorum libri sex* (Antwerp, 1613), bk. 6, 453–636, esp. 498.

40. Snyder, *Flattening the Earth*, 43–49, and Shirley, *Mapping of the World*, 137–42 (no. 119).

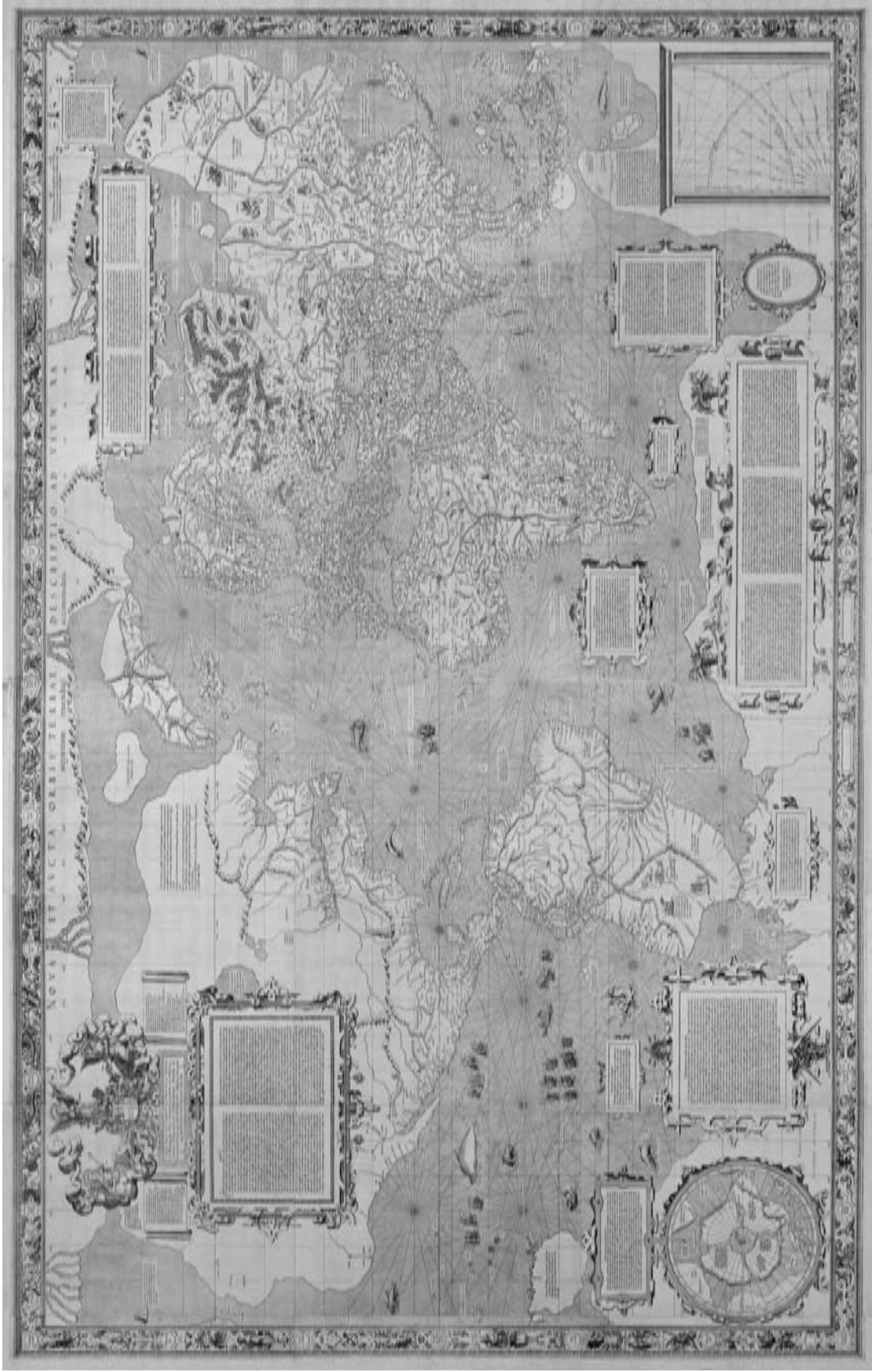


FIG. 10.12. THE MERCATOR PROJECTION, 1569. Although attempts have been made to cite precursors to Gerardus Mercator's concept of producing a map on which lines of constant compass direction were represented as straight, this eighteen-sheet printed map can claim to be drawn using the most famous projection of the Renaissance. The small diagram

inset at the lower right provides a graphic representation of the construction of the projection.
Size of the original: 124 × 202 cm. Photograph courtesy of the Öffentliche Bibliothek der Universität, Basel (Kartensammlung AA 3-5).

could follow a single compass setting (adjusted for magnetic declination) based on the bearing or azimuth of the straight line connecting the point of departure and the point of destination on the map.

Edward Wright, a Cambridge University professor and navigational consultant for the East India Company, later studied the Mercator projection, apparently independently. In his *Certain Errors in Navigation* (1599, rev. 1610 and 1657), he included “A Table of Latitudes” in which he provided the distance from the equator of each projected parallel, in increments of one minute, with a precision equivalent in modern terminology to four decimal places. His underlying calculations were of far greater accuracy than Mercator’s graphical construction. This combination of great precision and accuracy—and possibly national pride—led a number of writers, including Edmond Halley, to credit Wright rather than Mercator with the invention.⁴¹

Although use of the projection began slowly, Petrus Plancius used it for a world map for which the Dutch government granted him a twelve-year patent in 1592. After the patent expired in 1604, Willem Jansz. Blaeu decided to bring out another version in 1606–7.⁴² It was not until later that the Mercator projection became all too common in world maps used for geographic purposes in addition to navigation, which has remained an important use to the present. In promoting use of the projection for geographic purposes, a use unintended by Mercator, one cannot overlook the importance of the fact that Europe is portrayed with about twice its true area in proportion to countries near the equator.⁴³

PROJECTIONS FOR REGIONAL MAPS

The requirements of projections for maps covering smaller areas of the world are somewhat different than for world maps. At larger scales, the difference between key properties such as conformality and equivalence (equal area) may not be as evident. Simplicity of construction is thus uppermost. The most common projection for regional maps in the Renaissance became known as the trapezoidal because of its straight parallel parallels and straight converging meridians.⁴⁴ Used in a rudimentary form in 1426 by Conrad of Dyffenbach, the trapezoidal projection also appears on a map of central and southern Africa in the mid-fifteenth century Wilczek Brown codex of maps from Ptolemy’s *Geography*.⁴⁵ Nicolaus Germanus claimed it as his own invention in 1482 and used it in several manuscripts of Ptolemy’s *Geography*, beginning in 1466, and in the 1482 and 1486 printed Ulm editions.⁴⁶ The projection was often the basis for regional maps in other atlases, including those of Ortelius and Mercator. Mercator used a modification of the trapezoidal projection for larger territories in the first and second parts of his atlas (1585 and

1589). In this projection, the parallels of true scale are not the outer ones, but they are about one quarter and three quarters of the distance between the limiting latitudes to reduce the overall distortion.⁴⁷

PROJECTIONS FOR CELESTIAL MAPS

The energy devoted to the construction of astrolabes in the Middle Ages was astounding.⁴⁸ Central to the effort was the construction of star maps to appear on the rete, while the tympana (plates) bore networks of lines of equal azimuths and altitudes that were latitude dependent. The stars were projected for the rete using a generic, polar stereographic projection because it was conformal and displayed the movement of the heavens in relation to the horizon as perceived by the observer. The angle between any three stars in the sphere is the same as the angle between the projection of these stars onto the plane. Furthermore, any circle in the celestial sphere, such as the ecliptic, celestial equator, or celestial tropics, could be represented as a circle on the projection. The principles of the stereographic were known to Hipparchus, and Ptolemy wrote a manual on its use, the *Planisphaerium*. The equatorial aspect of the stereographic was employed by the Arab astronomer al-Zarqello (Azarquiel) of Toledo in the eleventh century in an astrolabe design.⁴⁹

The use of the stereographic projection carried over into the printed celestial maps of the Renaissance, including Albrecht Dürer’s star maps of the northern and southern celestial hemispheres (1515). Dürer’s graticule is

41. Snyder, *Flattening the Earth*, 47–48 and n. 107.

42. Günter Schilder, “Willem Jansz. Blaeu’s Wall Map of the World, On Mercator’s Projection, 1606–07 and Its Influence,” *Imago Mundi* 31 (1979): 36–54.

43. Christa Binder and Ingrid Kretschmer, “La projection mercatorienne,” in *Gérard Mercator cosmographe: Le temps et l’espace*, ed. Marcel Watelet (Antwerp: Fonds Mercator Paribus, 1994), 192–207, esp. 193, and Mark Monmonier, *Rhumb Lines and Map Wars: A Social History of the Mercator Projection* (Chicago: University of Chicago Press, 2004).

44. Snyder, *Flattening the Earth*, 8–10.

45. See plate 10. On Dyffenbach’s maps, see Richard Uhden, “An Equidistant and a Trapezoidal Projection of the Early Fifteenth Century,” *Imago Mundi* 2 (1937): 8, and 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), pl. I. On the Wilczek-Brown Codex, see O. A. W. Dilke and Margaret S. Dilke, “The Wilczek-Brown Codex of Ptolemy Maps,” *Imago Mundi* 40 (1988): 119–24.

46. See Nicolaus Germanus’s dedicatory letter to Pope Paul II from the Ulm 1482 edition, quoted in Nordenskiöld, *Facsimile-Atlas*, 14.

47. Johannes Keuning, “The History of an Atlas: Mercator-Hondius,” *Imago Mundi* 4 (1947): 37–62, esp. 39.

48. R. T. Gunther, *The Astrolabes of the World*, 2 vols. (Oxford: Oxford University Press, 1932).

49. Emilie Savage-Smith, “Celestial Mapping,” in *HC 2.1:12–70*, esp. 28–31, and Keuning, “Geographical Map Projections,” 8.



FIG. 10.13. GNOMONIC PROJECTION BY FRANZ RITTER, 1610. The gnomonic projection, in which all great circles are represented by straight lines, was usually employed for sundials. In this example, centered near Nuremberg, a representation of the earth has also been incorporated to show the

relative time at various places. The deformation of shape away from the center is dramatically shown.

Size of the original: 29.5 × 36 cm. Photograph courtesy of the Newberry Library, Chicago (Novacco 2F7).

limited to ecliptic longitude lines radiating from the central ecliptic poles, but star positions indicate the stereographic. Johannes Honter included some small circles of the celestial graticule in his pair of star maps in 1532.⁵⁰

Other projections were used for star maps in the period. I have already mentioned Flamsteed's use of the sinusoidal equal-area projection. Wilhelm Schickard, a German astronomer and mathematician from Tübingen, was the first of several seventeenth- and eighteenth-century mapmakers to use the conic projection for celestial maps.⁵¹ Johannes Kepler employed the equatorial aspect of a gnomonic projection for a star map of 1606, and various aspects were used for constellations in a 1612 atlas by Christoph Grienberger and for some star charts by his colleague Orazio Grassi in 1619.⁵²

Projections for sundials provide a specialized case. The gnomonic projection has a direct connection with sundial design. The angles between the hour markings on a sundial designed for a particular latitude are identical with the angles between the meridians on a gnomonic projection centered at the same latitude, counting each 15 degrees of longitude from the central meridian as one more hour from noon. To allow one to read time, the

50. Snyder, *Flattening the Earth*, 22.

51. Wilhelm Schickard, *Astroscopium, pro facillima stellarum cognitione noviter excogitatum* (Tübingen, 1623; Nordlingae, 1655), referenced and reproduced in Deborah Jean Warner, *The Sky Explored: Celestial Cartography 1500–1800* (New York: Alan R. Liss, 1979), 224–28.

52. Warner, *Sky Explored*, 135, 100, and 99, respectively.



FIG. 10.14. MAP OF EUROPE AND NORTH AFRICA FOR USE WITH A SUNDIAL, DRAWN BY ERHARD ETZLAUB ON A "MERCATOR-LIKE" PROJECTION, 1511. The increasing spacing of the parallels of latitude toward the north pole (south is at the top) have led some authors to cite this map as a precursor to the Mercator projection, but because the map functioned as a sundial and not a map for the use of navigators, any direct link is unlikely.

Size of the original: 11.8 × 8 cm. Photograph courtesy of the Germanisches Nationalmuseum, Nuremberg (WI 28).

gnomonic map is first rotated so that the north pole is south of the center of projection rather than north. Then the triangular gnomon of the sundial is placed with its base along the central meridian and its shadow-casting back touching the north pole on the map. The local sun time is indicated by the meridian along which the shadow of the sun then falls.

The use of the gnomonic projection for maps during the Renaissance was rare, apparently postdating 1600. One early geographic example is an oblique aspect of the gnomonic centered near Nuremberg, with a 5 degree graticule, which was published in 1610 (fig. 10.13).⁵³

Erhard Etzlaub used a projection similar to Mercator's in appearance if not in function for a small map limited to Europe and North Africa on the cover of some sundials constructed in 1511 and 1513 (fig. 10.14). It extended in 1 degree intervals of latitude from the equator to 67°N, with spacing that increases in a way similar to that of the

Mercator projection. Englisch has postulated a direct link between Etzlaub's map and Mercator's, suggesting that the projection should be called the Etzlaub-Mercator.⁵⁴

CONCLUSION

By 1500 it was already clear that the classical frame of Ptolemy's maps would no longer contain the new geographical discoveries in the hemispheres opposite the *oikoumene* in the south and west. Yet Ptolemy's *Geography* did possess the theoretical seeds—a system of world-wide coordinates—to allow this transformation to take place. When the *Geography* arrived in Western Europe at the end of the fourteenth century, it was first translated by Jacopo Angeli because of the perceived authority of the ancient text. Humanistic interest in Ptolemy's text as translated into Latin was far greater than in the maps.

By the last quarter of the fifteenth century, however, the *Geography* was a bestseller among illustrated printed books. When world trade beyond Europe expanded to a circumnavigated world, an effective method of mapping it with latitude and longitude was already understood in scholarly circles. Even then, the early interest in coordinate systems and projections was motivated more by an interest in mathematical games and geometric shapes (circle, sphere, oval) expressing the ideals of perfection and wholeness than by an interest in pinpointing places for wayfinding or inventorying places for imperial ambitions. The empirical data for compiling an accurately plotted map were largely unavailable until the position of a large number of key astronomical observatories had been fixed in the seventeenth century as Eckebrecht's 1630 map represents so clearly.

This may explain why workaday maps for wayfinding (such as nautical charts) were rarely compiled using longitude and latitude until later in the sixteenth century. This is illustrated by the parallel development of two entirely different kinds of world map, the *carta marina* and the *cosmographia*. The first looked like a nautical chart; the second like a world map out of a geographical textbook. Maps of the two types were published in pairs: Francesco Rosselli sold a pair around 1508 that are still found together, and Martin Waldseemüller's 1507 *Vniversalis cosmographia* and 1516 *Carta marina* are well-known larger examples.⁵⁵ It is tempting to postulate that the practice oc-

53. Published in Franz Ritter, *Speculum solis* (Nuremberg: Paul Fürstens, 1610), referenced and reproduced in David Woodward, "Early Gnomonic Projection," *Mapline* 13 (1979): [1–2]. See also Shirley, *Mapping of the World*, 290–91 (no. 270).

54. Brigitte Englisch, "Erhard Etzlaub's Projection and Methods of Mapping," *Imago Mundi* 48 (1996): 103–23.

55. See Shirley, *Mapping of the World*, 32–33 (nos. 28 and 29 [Rosselli]), 29–31 (no. 27 [Waldseemüller]), and 46–49 (no. 42 [Waldseemüller]), and see also plate 16 and figures 1.3 and 9.9.

curred as early as the last decade of the fifteenth century; perhaps a *carta marina* version of Henricus Martellus Germanus's large cosmography of ca. 1490 will someday emerge. The pairing was later evident in editions of Ptolemy's *Geography* and other cosmographies in the sixteenth century. The combination of these two types of world map was achieved in the elegance of the Mercator projection in 1569. It provided a plane chart that could be compiled with longitude and latitude values.

Ease of construction was certainly an important concern for plane charts and regional maps on trapezoidal projections that continued to be used into the eighteenth century. Graticules of meridians and parallels constructed entirely with straight lines, especially in the projections attributed to Marinus and Nicolaus Germanus, gave way only in part to those employing a mixture of circular arcs and straight lines, especially the conic-like projections of Ptolemy and of those who improved upon his designs, as well as oval and globular types of projections. Straight lines were also used for Mercator's new projection for navigation, but the property of straight rhumb lines was central to the use of his projection rather than the rectilinear graticule; the mathematical spacing between the parallels was the complicating factor.

The special mathematics needed for the stereographic and gnomonic projections had been understood in the

Middle Ages in the context of astronomical instruments. Theoretical properties of equal area and conformality were understood by mathematicians such as Johannes Stabius, Johannes Werner, Johannes Schöner, Gemma Frisius, and Oronce Fine, as is illustrated by a bewildering variety of cordiform projections with complex curves. Elegant solutions were proposed, and fierce rivalries as to the primacy of a particular invention (such as the Mercator projection) were not only common then, but have also continued today on the part of modern historians.

The mathematics was still largely based on Euclid, as is shown by general writing about projections during the period. Artisans who made instruments, such as navigators, were not always skilled in mathematics, and the practical need for it was not always evident. What was missing was a means of describing projections and their properties by means of algebraic equations. It remained for the dramatic development of calculus in the late seventeenth century to answer the need for more mathematically based map projections. Although the major projection types in use in the modern era were in place by the end of the period under consideration, a roadblock had been encountered, and a Leibnitz, Lambert, or Gauss was needed to break through it.