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Cadastral Map. See Property Map: Cadastral Map

Cadastral Surveying. Cadastral surveying is the process that led to the production of cadastral maps, though not all cadastral surveys were map-based. It was used in both the Old and New Worlds to demarcate property boundaries of individuals, institutions, or communities. This entry focuses on the survey process, and it reviews practices in the Netherlands, Denmark, and some German states as examples of Old World cadastral surveying in the seventeenth and eighteenth centuries and explains how these methods were adapted for the New World using some examples from North America (much of this entry draws directly from the fuller treatment by Kain and Baigent 1992).

In the northern Netherlands the development of cadastral surveying was closely linked to the management of reclaimed polder farmland. Where land was abundant and of little value, the costs of surveying rapidly exceeded its perceived benefits. In the polder areas of the Netherlands, the population was dense and land relatively scarce. Not only was it not abundant, it was not free: considerable amounts of labor, skill, and money had to be invested before it existed at all. The cost of a map was thus small in comparison with the overall cost of land and with the benefits to be derived from the knowledge that a survey would provide.

Training for cadastral surveyors gradually became more systematized, exemplified by the Danish and German experience. One obvious aspect of Danish cadastral cartography was the increasing availability of instruction books and increasingly systematic training. The influence of cartographers such as Thomas Bugge in the late eighteenth century helped to standardize the conventions used by cadastral cartographers (Bugge 1795). Until the 1780s, surveyors in Denmark were trained in a wide variety of ways. The Danish Landkadetakademi trained some military surveyors, and others received their training abroad. Some received fairly formal instruction; others learned their craft in the field from experienced surveyors; still others were self-taught. This diversity of backgrounds gave rise to great variety among early maps. Greater standardization was institutionalized in the 1780s by setting examinations for aspiring surveyors and survey inspectors; they had to pass tests in mathematics, surveying, and land reallocation before they could be appointed to public bodies. The standardization in style and training was matched by increasing uniformity in units of measurement used (Jensen 1975).

This broad picture of systematization over the two centuries was mirrored in the German states. In Hessen-Kassel, comprehensive surveying to reform taxation began in 1680, and in 1699 a new tax office, the Steuerstube, was set up and issued regulations to ensure that surveyors used uniform linear and areal measurements. Little else was regulated, and the maps that the surveyors sent in showed great individuality of style. In the nearby prince-bishopric of Fulda, systematic cadastral surveying began in 1718. Work proceeded far more rapidly than in Hessen-Kassel and the maps (fig. 135) are far more uniform, with surveyors working to strict instructions governing the use of symbols and color washes (Wolff and Engel 1988). In Baden-Württemberg, the authorities of the Imperial City of Schwäbisch-Hall consulted officials in Ulm, Rothenburg, and Nuremberg, which had recently carried out mapped cadastres. Cadastral surveying in Schwäbisch-Hall was led from 1699 by Daniel Meyer from Basel. He already had considerable experience as a cadastral cartographer and came from a long-established Swiss mapmaking family. Meyer was called to Schwäbisch-Hall to survey and map the town itself, but he arrived in May, just when the townspeoples' gardens were coming into flower. To minimize the damage that would inevitably accompany the survey, it was decided that he should begin work in the rural areas. He would start with the fallow fields; then, when the harvest was

FIG. 135. CADASTRAL MAP OF MABERZELL, HESSEN, 1722. "Tractus V: Geometrischer Grund Riß über die Fluhr und Marcke des Dorfes Maberzell" is a typical example of the Fulda cadastral maps of the eighteenth century.

Size of the original: 73 × 100 cm. Image courtesy of the Hessisches Landesarchiv beim Staatsarchiv Marburg (Best. Karten P II 13568, Bl. 5).

safely in, go on to the arable areas; and then return to map the town. The Schwäbisch-Hall authorities seem to have shown remarkable sensitivity in this: cadastral surveys elsewhere often ran into trouble because surveyors and their assistants damaged crops and aroused the opposition of farmers.

In North America cadastral surveying played a key role in land settlement, but the precise relationships between cadastral surveying and settlement form from one colony to another varied between two broad types. Known as the New England and Virginia methods, they reflected radically different attitudes to political and social control. The Puritan colonies exerted social control over land by the orderly, planned granting of blocks of land to town communities. These were surveyed first and then divided into farms. In colonies south of Pennsylvania, landholdings were larger and granted to individuals who were free to pick and choose the best land as they perceived the realities of the physical environment, and tracts were claimed first and then surveyed by metes and bounds methods (fig. 136) (Price 1995).

From 1642, it was a legal requirement in Virginia that all surveyors "shall deliver an exact plott of each parcell surveyed and measured" (quoted in Hughes 1979, 48). The 1642 enactment coincided with a period of contentious disputes over boundaries; from the 1640s a series of government measures was designed to tighten survey and land patent procedures. In Maryland, early seventeenth-century surveying of tidewater land grants was similarly slipshod. Carville Earle (1975) recounts how in All Hallows Parish, surveyors simply measured off a desired distance along an estuary shore and projected the other three lines to produce a rectangular lot and then calculated its area. Field measurements of distance, direction, and area were also very approximate. In Earle's opinion, surveyors who measured distance with a Gunter's chain before about 1670 were few and far between. In fact, the Maryland Assembly of 1674

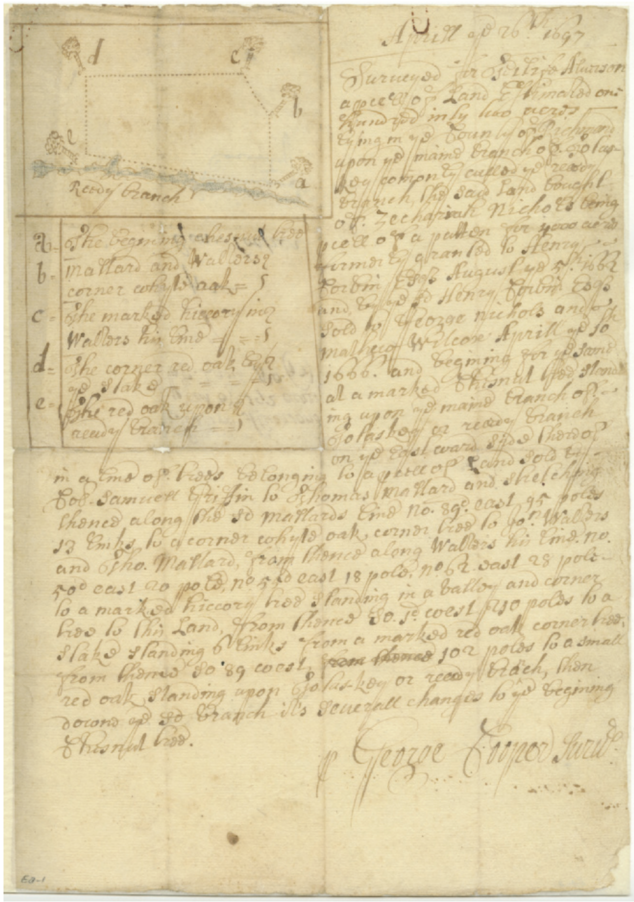

FIG. 136. GEORGE COOPER, MANUSCRIPT SURVEY FOR TELEIFE ALVERSON, GRANT OF 192 ACRES IN RICHMOND COUNTY, VIRGINIA, APRIL 1697.
Size of the original: ca. 30 × 21 cm. Image courtesy of the Library of Virginia, Richmond (Northern Neck Surveys Richmond County, Box 40).

recognized the imprecision of surveys and passed a law that provided a doubling of fees for surveyors who used chain and circumferentor (Earle 1975, 184).

Though the position of land plats in the settlement process differed from colony to colony in the eighteenth century, the method of survey by compass or circumferentor (a primitive theodolite) and chain was much the same, whether of individual tracts in Georgia, of townships in New Hampshire, or of *seigneuries* in Quebec. Didactic treatises published for colonial use adapted Old World surveying and mapping techniques to colonial needs, advocating in particular the compass traverse for surveying new lands. One of the reasons John Love wrote his *Geodæsia* (1688) was that he had earlier seen "Young men, in *America*, often nonplus'd so, that their Books would not help them forward, particularly in *Carolina*, about Laying out Lands, when a certain quantity of Acres has been given to be laid out five or six times as broad as long" (Love 1688, preface).

An excellent account of the actual practice of metes and bounds survey in the field during the eighteenth century is given by William Roome in his history of land surveying in the colony of East Jersey (1883, 45):

> The Deputy-Surveyor, when on a land expedition, would sally out on horseback, his compass duly boxed, and his chain in his saddle-bags behind him. Arriving at the point where the land lay which was to be surveyed, and where by previous appointment his assistants were to be found, the first step was to cut a straight stick . . . for a "Jacob's staff" [i.e., a support for the compass]. . . . All things being now ready, the compass was placed at the beginning point and the bearing decided on, taken, and the flag-man sent ahead and placed in position. The compass was then removed to the flag-man's point, but no back sight left at the point it was removed from. The bearing was here again taken at the same degree as before (by the needle's point) and the flag-man again sent forward, and this was continued until the survey was completed—the chain-bearers following directly after the surveyor as nearly on the line as practicable. . . . Often no flag was used ahead at all. The surveyor would set up his compass, and with the remark that a certain tree, rock, or some other object ahead was on the line, or within a rod, or a rod and a half of it, perhaps, on either side, as the case might be, he would direct his chain-bearers to "go for it" and they would all start for the place designated. . . . When it was conceded that the chain had been carried "too crooked" an allowance would be made by guess "to make the distance about right." And this mode would be continued until the lot was completed.

An increasing number of surveying textbooks published in America from the second half of the eighteenth century exemplifies both the continuing need and existing market for works of instruction. Pre-Independence texts included Thomas Abel's *Subtensial Plain Trigonometry* (1761) and John Carter's *The Young Surveyor's Instructor* (1774). In 1785, the year in which the presettlement mapping of the federal public domain began, the fourth edition of Robert Gibson's *A Treatise of Practical Surveying* appeared: "Adapted to the Use of American Surveyors, Some Parts of the Work have been abridged, and other Parts totally omitted, as being of little or no Use to the American Surveyor" (Gibson 1785, title page and advertisement). The prodigious survey and mapping activity generated by the 1785 and later land ordinances was matched and serviced by additional texts published before the end of the eighteenth century, including those by George Wall (1788), John Clendinin (1793), Samuel Moore (1796)—containing a section on the recovery of lost boundaries when original survey markers have disappeared—Solomon Dewey (1799), Zachariah Jess (1799)—whose book was "adapted for the easy and regular instruction of Youth, in our American schools"—and Ezekiel Little (1799).

Once land had been improved by clearance and settlement, careless surveying created multifarious problems. When land was thought of as limitless, there was little incentive for accuracy. The recording of survey work on a plat for public witness was but one symptom of a developing capitalist attitude toward land in the tidewater colonies as social and economic changes enhanced the value of survey and provided a role for property maps in the process of land settlement. By the middle of the eighteenth century, attempts were being made in other colonies to regulate the manner of surveying and mapping. From 1747 surveyors in New Jersey for example, were required to submit composite cadastral maps of all the land allocations in the county in which they worked (Wacker 1975). Such systemization was to reach its apogee in the mid-nineteenth century's age of cadastral surveys.

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SEE ALSO: Property Map: Cadastral Map; Property Mapping; Taxation and Cartography

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Calcografia Camerale (Copperplate Printing Administration; Rome). Pope Clement XII established the Calcografia Camerale (today part of the Istituto centrale per la Grafica) in 1738, as proposed by his nephew Cardinal Camerlengo, Neri Maria Corsini. A cultural innovation of the Corsini papacy, the Calcografia acquired the stock of the prestigious De Rossi print firm, more than 9,000 individual engraved plates (Woodward 2007, 777–79). The pope declared that his aim was to "promote the magnificence and splendour of Rome" and to "advance the studies of youthful scholars of the liberal arts" (Clemente XII, 15 febbraio 1738, Archivio di Stato, Calcografia Camerale, B.1 fasc.7; Petrucci 1953, 3). His act of patronage was strikingly modern in character because it not only blocked the proposed sale of De Rossi's visual records of the history of Rome to English merchants, but it also foreshadowed papal policy for using prints as mass media since their ease of distribution was an efficient means of propaganda.

The De Rossi collection consisted largely of views and maps of Rome, numerous plates cut by sixteenth-century Italian engravers, and a series of portraits of cardinals. Throughout the eighteenth century, the production of the Calcografia was organized by the genres found in De Rossi's last *Indice delle stampe* (the sales catalog of 1735). The *Indice* began with the series entitled *Mercvrio geografico*, the oldest and most important collection of geographical maps in Italy, a veritable general atlas of the world. The *Mercvrio* listed 185 plates, including the work of engravers such as Giorgio Widman, Jan L'Huillier, and Giovanni Battista Falda and of cartographers such as Augustin Lubin, Giacomo Filippo Ameti, and Giacomo Cantelli da Vignola.

Assembled according to seventeenth-century criteria established by the print dealer De Rossi, this rich collection of maps played a decisive role in the first publications issued by the Calcografia in the difficult early years of its existence, when the new institution struggled with economic difficulties, the lack of appropriate premises, and the dire management of Giovanni Domenico Campiglia. A painter linked with the Corsini family, Campiglia was appointed as both artistic director and head of administration, but he was completely unversed in the demands of the print market. Fortunately, however, final decisions regarding the purchase or commission of plates lay not with him but with the treasurer general of the Camera Apostolica.

Although scholarly circles in Rome were aware of the contemporary European debate regarding the methods of land surveying as they affected the production of maps, the main stimulus for the continuing interest in cartography came from elsewhere: the desire to enlarge the existing collection through the addition of other well-known seventeenth-century works. Notable among such acquisitions were Israël Silvestre's perspective map of Rome (1687) and Pietro Sante Bartoli's view of the Civitavecchia aqueduct, both included in the new edition of the *Mercvrio geografico* (1741).

To update the cartography of the collection, the engraver Giovanni Petroschi was commissioned to review the engraving of the existing copperplates and also to prepare a new map of the course of the River Po. However, these first years of the Calcografia reveal the absence of any precise program; it was the members of the circle of Cardinal Alessandro Albani, such as Diego de Revillas, amateur scientist and mathematician at Rome's La Sapienza university, and the marchese Alessandro Capponi, who in 1736 encouraged Giovanni Battista Nolli to prepare a new map of Rome, finally published in 1748 (Bevilacqua 1998, 19–20; and see fig. 609). Yet the fact that the twelve plates for Nolli's *Nuova pianta di Roma* were not donated to the Calcografia until 1938 testifies to the scant influence that the institution had on cartography in Rome. In effect, throughout the eighteenth century, popes considered the Calcografia not so much an institution for producing cartography as a means of producing personal propaganda. Hence, the commissions tended to glorify the papacy or more sharply define the territories of the Papal States.

Increasing attention was dedicated to producing new views of the city. Benedict XIV made efforts to organize the activities of the Calcografia more adequately, appointing his own secretary of state, the learned collector Cardinal Silvio Valenti Gonzaga, as administrator of the Calcografia from 1747 to 1756. The pope himself was a refined collector of prints; at his behest the *Pianta del corso del Tevere e sue adiacenze* (1744) was produced, which records the rerouting of the river by engineers Andrea Chiesa and Bernardo Gambarini. Engraved by Carlo Nolli, this print was probably one of the first on which Giovanni Battista Piranesi worked for the Calcografia.

In 1755, with Gonzaga still as head, the Calcografia published the *Nuova carta geografica dello Stato Ecclesiastico* (see fig. 90), engraved by Felice Polanzani and Gaetano De Rossi for the *De litteraria expeditione* by the Jesuits Christopher Maire and Ruggiero Giuseppe Boscovich, a geodetically surveyed map of the Papal States. Boscovich, an internationally renowned mathematician who taught at the Collegio Romano, was one of an *accademia* of scholars who enjoyed the hospitality of Cardinal Gonzaga's Porta Pia villa.

Until the end of the century the activities of the Calcografia were hampered not only by lack of funds (excessive bureaucracy prevented competition with private printers) but also by continuous relocation, hindering the effective organization of its activities. In 1772 Gaspare Sibilla took over from Campiglia as manager, and in 1780 the Calcografia moved its premises to the ground floor of the Palazzo della Stamperia. However, only in 1786, when Giuseppe Valadier became administrator, did a real plan of action emerge: a reorganization allowing the Calcografia to compete with private printers. Valadier wanted to update the catalog of prints on sale, cutting back on those issued from the De Rossi cartographic collection; not only were the plates for these maps worn by excessive use, but they were rendered somewhat obsolete by new geographical discoveries. By 1792 the Calcografia began to commission new maps, publishing the first volume of its *Nuovo atlante geografico universale* (fig. 137), which contained 182 maps in three volumes, engraved by Giovanni Maria Cassini, who also engraved Giuseppe Morozzo della Rocca's large *Il patrimonio di S. Pietro* (1791). The 1797 *Indice delle stampe* shows the reorganization of genres, beginning with the views and maps of *Roma antica e moderna*, continuing with prints of paintings organized according to artist. Until this reorganization, cartography as exemplified by the *Mercvrio geografico* had assumed a place of pride at the beginning of the catalog; now maps were relegated to its last pages. The program of modernization implemented by Valadier led to further serious cartographic losses in the *Indice delle stampe* of 1806, which omits the seventeenth-century maps of Rome by Antonio Tempesta and Falda and the views of the city by Giacomo Lauro (all works from the De Rossi collection). In fact, just two years earlier, a total of 3,702 copperplates had been melted down so that new ones might be engraved—a decision guided by the consideration of plates as working tools rather than artistic artifacts in their own right. At the end of the eighteenth century the only important cartographic commission was the fifteen-plate *Atlante d'Italia* (1797–1805). However,

FIG. 137. GIOVANNI MARIA CASSINI, *L'ITALIA*, 1790. From volume 1 of *Nuovo atlante geografico universale* (Rome: 1792), map n. 23. Engraving and etching on copper. Size of the original: ca. 34.5 × 47.0 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

by this time the Calcografia appears to have focused almost exclusively on the publication of views of Rome and its monuments. Furthermore, the increasing number of commissions for engravings of existing paintings or works of sculpture emphasized the Calcografia's desire to meet the demand of travelers and pilgrims with this growing genre in the coming century.

GINEVRA MARIANI

SEE ALSO: Cassini, Giovanni Maria; Map Trade: Italian States

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California as an Island. In 1747, Fernando VI of Spain declared without equivocation in a royal decree that California was not an island, ending more than a century of geographical confusion over the precise shape of the Spanish territories known collectively as California, a myth first promulgated in print graphically on the title page of Antonio de Herrera y Tordesillas's *Novvs* *orbis, sive Descriptio Indiae Occidentalis* (1622). The explorations of the Croatian Jesuit Ferdinand Konšćak (Konschak, Konsag), sent to reconnoiter Baja California in 1746, provided the final assurances to the reigning monarch that the land off the western coast of New Spain, which also contained the region known as New Albion discovered by Sir Francis Drake in the late sixteenth century, was in fact connected to the mainland (Altic 2012). But the interpretive oscillations between an insular and a peninsular shape of California swung through the seventeenth and eighteenth centuries, confounding those who were convinced that earlier maps and charts had correctly displayed a peninsular form of Baja California.

Indeed, the first explorations of the Gulf of California had shown Baja to be a peninsula. As early as 1539, having returned from Spain after capturing the seat of the Aztec empire at Tenochtitlan (Mexico City), Hernán Cortés sent two ships under the leadership of Francisco de Ulloa to extend the reaches of his conquests northward from Mexico's Pacific coast. Although Ulloa himself did not return from this voyage, one of his two ships managed to return to New Spain with the important news that the area then known as Santa Cruz was a peninsula, not an island. (The Gulf of California remains known today as the Sea of Cortés.) Important sixteenth-century world maps, such as Abraham Ortelius's *Americae sive novi orbis* (1570), Jodocus Hondius's *Vera totivs expeditionis navticæ* (1595), and Cornelis van Wytfliet's map of New Granada and California (1597), clearly show a thin "red sea" (Mer Rouge, Mar Vermejo) stretching northward between the peninsula of Baja California and the mainland; nowhere in these early depictions does the Gulf of California cut westward to reconnect with the Pacific Ocean.

Following the clear graphical evidence of these earliest maps, debate over whether California was an island or a peninsula flared up again in the early seventeenth century, primarily due to the journal and map produced by the Carmelite friar Antonio de la Ascensión, who had accompanied a reconnaissance mission led by the Spanish merchant Sebastián Vizcaíno. Vizcaíno had traveled frequently between Manila and New Spain, as well as up and down the Pacific coast of North America. In 1602, Vizcaíno captained a fleet from Acapulco to explore the northern coast of California as far as Cape Mendocino. Although the expedition was costly in human terms, it was the basis for a personal account of the journey written by Ascensión. A self-proclaimed student of cosmography at the University of Salamanca, Ascensión purported in his account to have assisted the expedition's chief cosmographer in collecting information about the region's topography. He also relied on indigenous testimony when asserting that the Gulf of California was in fact a sea that connected the inland waterway with the ocean to the west. Dutch pirates may have intercepted one version of Ascensión's map, now lost, but another copy, also lost, likely served as the primary source for the myth of an insular California.

From the 1620s, following Ascensión's account, many seventeenth-century maps began to show the Baja California peninsula as an island, including Henry Briggs's *The North Part of America* (1625), published in Samuel Purchas's *Haklvytvs Posthumus or Pvrchas His Pilgrimes*, Henricus Hondius's *America Septentrionalis* (1636), and Nicolas Sanson's *Le Nouveau Mexique et la Floride* (1656). The myth persisted well into the eighteenth century, in spite of the circulation of the map *Passage par terre a la Californie* by Eusebio Kino, SJ, based on his exploration of the Baja Peninsula from 1698 to 1701 and published in the *Lettres édifiantes* (or Jesuit Relations) (1705). Herman Moll's map of North America (1719) shows a wide Californian island off the western coast of North America that bears little resemblance to earlier depictions of the island as a peninsula, with a small channel running between its northern edge and the North American mainland. Interest in the configuration and size of California (peninsula and region) formed part of a larger debate on the existence and feasibility of a northwest passage, the breadth of North America, and the size of the Pacific (Engel 1776, accompanied by Robert de Vaugondy's map [fig. 138]; Broc 1975, 167–72, 307–8). Matthäus Seutter's *Novus orbis sive America Meridionalis et Septentrionalis*, first published in midcentury, exemplifies the reluctance of European commercial map publishers to abandon the image of an insular California even after the idea was being seriously re-assessed in the larger scientific community.

NEIL SAFIER

SEE ALSO: Imaginary Geographies and Apocryphal Voyages; Geographical Mapping

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FIG. 138. DIDIER ROBERT DE VAUGONDY, *CARTE DE LA CALIFORNIE.* Robert de Vaugondy's map, designed to accompany the entry on California in the *Supplément à l'Encyclopédie,* shows the chronological development of various states of knowledge concerning the shape of the California peninsula or island (according to maps of 1604, 1656, 1700, 1705, and 1767). Originally published in the *Suite du Recueil de planches, sur les sciences, les arts libéraux, et les arts méchaniques, avec leurs explication* (Paris: Panckoucke, Stoupe, Brunet, 1777). Size of the original: ca. 31.0 × 38.5 cm. Image courtesy of Barry Lawrence Ruderman Antique Maps, La Jolla.

Canal Map. See Transportation and Cartography: Canal Map

Canal Survey. See Transportation and Cartography: Canal Survey

Carte de France. During the seventeenth century, administrative centralization encouraged the creation of detailed maps covering all of France and prompted cartographers to improve and develop their production. In 1648, Nicolas Sanson proposed substituting *généralités*—administrative divisions whose importance would be increased by Louis XIV—for the *gouvernements généraux* used in his previous map of France completed after 1643 (in thirty sheets, but not conserved) (Pastoureau 1982, 149–50). Sanson's large map of 1652–53, *Carte et description generale dv tres-havt, tres-pvissant et tres-chrestien royavme de France* (ca. 1:880,000), was thus divided into *généralités* and announced the intention to prepare more detailed maps, but that program was never realized. Instead, between 1656 and 1676 Sanson published a series of diocesan maps, usually at ca. 1:234,000, prepared first by himself and then by his son

Guillaume (Pastoureau 1984, 417–26). Although these documents conveyed a reassuring vision of a space subject to royal power, the realization of that vision was more complex. Methods would have to be harmonized and new surveys conducted to complement or replace existing maps.

The man driving this change was Louis XIV's minister, Jean-Baptiste Colbert. In 1663–64 he wanted to assemble all existing maps of France in order to correct them, if necessary, and to mark the numerous, complex administrative divisions on them. A report from 1665, attributed to Nicolas Sanson, met the minister's requirements. Its ambitious goal was to map all of France in great detail, but using the compilation method of the *géographes de cabinet*. Maps from existing collections (notably those of the ministry of war) would be used and administrative divisions added. Where new surveys were required, the "web" technique would be used: local observers would note directions and evaluate distances from the central point of a circle (Trénard 1975, 83–88). In 1666, a report was presented to the newly created Académie des sciences on existing procedures, and two years later Colbert requested that working methods be defined. The Académie, having heard from Guillaume Sanson, decided to prepare an experimental map of the environs of Paris under the direction of Gilles Personne de Roberval and Jean Picard. Triangulation would cover the whole mapped region. Picard, Jean-Dominique Cassini (I), and Jean Richer verified the surveys in 1669. The *Carte particuliere des environs de Paris* (see fig. 4) was published in 1678 at the scale of one ligne (2.25 mm) per 100 toises (194.904 m), or ca. 1:86,400, the scale of the future *Carte générale et particulière de la France* (Pelletier 2013, 56n36). Like most seventeenth-century maps, however, it did not indicate any roads (Gallois 1909, 197–204). To show the real extent of French territorial control, Cassini I and Philippe de La Hire prepared an initial map in 1679–82, presented to the Académie in 1684 and published in 1693, the *Carte de France corrigee* (see fig. 625). The map gave the latitudes and longitudes of points situated on the perimeter of the realm and compared the new outline to the old one as shown on Guillaume Sanson's map of 1679 (Konvitz 1987, 5–8).

In 1681 Picard presented a very innovative program that took more than sixty years to complete. He proposed establishing a general framework of chains of interlocking triangles based upon the Dunkirk-Perpignan meridian and following terrestrial and maritime frontiers (Gallois 1909, 292–93). Three Cassinis (Jean-Dominique [I], Jacques [II], and César-François Cassini [III] de Thury) and their two cousins, Giacomo Filippo Maraldi (Maraldi I) and Giovanni Domenico Maraldi (Maraldi II), participated in this vast enterprise. Its several objectives included: establishing the realm's outline through geometric measurements, offering new data on baselines to cartographers, and contributing to the calculation of the dimensions and form of the terrestrial globe.

Begun by Jean Picard, measuring the degrees of the Paris meridian by triangulation was entrusted in 1683 to Cassini I and La Hire, but it was soon interrupted. Cassini I and Cassini II resumed measurement in 1700 and 1701, and Cassini II completed it in 1718, using its results to argue that the earth was elongated toward its poles. Even in 1733, the *contrôleur général des Finances*, Philibert Orry, still supported Picard's program, because it aided the development of communication systems entrusted to the administration of the Ponts et Chaussées (bridges and highways). Cassini II, accompanied by his sons, his cousin Maraldi II, abbé Jean Delagrive, and François Chevalier, began in 1733 to measure the western portion of the perpendicular to the Paris meridian. This measurement gave degrees of longitude smaller than those congruent with a spherical earth and confirmed Cassini II's erroneous conclusion that the earth was elongated toward its poles (Cassini II 1735, 402). From 1735 to 1737, the Cassini family, with the help of abbé Nicolas-Louis de La Caille, measured the northern and southern coasts of Brittany, the Norman coasts with an extension to Dunkirk, the Atlantic coasts from Nantes to Bayonne, and the perpendicular Bayonne-Antibes (Cassini III 1741). In 1739, Cassini II decided to compare the measurements of the degrees of the meridian with astronomical measurements performed along this line by Cassini III and La Caille (Cassini III 1744). The general triangulation of France, organized around the Paris meridian, its perpendicular, and parallels to these lines, included nearly 800 triangles. It was "a sort of geometric fortification that secures in the most unalterable manner the present extent of the realm" and it covered all the provinces (Académie royale des sciences 1749, 75). Each year Cassini III presented Louis XV with a map showing the progress of the enterprise (Cassini III [1745], 22).

Two maps showed the general triangulation. The first, *Nouvelle carte qui comprend les principaux triangles qui servent de fondement à la description géométrique de la France* (ca. 1:1,772,000), in one sheet, was the work of Maraldi II and Cassini III. Completed in 1744 and presented to the Académie in 1745, it went through several states marked by the addition of the secondary triangulation and the regular sheet lines of the future *Carte de France* (see fig. 19). The second map, *Carte qui comprend touts les lieux de la France qui ont été déterminés par les opérations géométriques* (ca. 1:886,000, first in sixteen sheets and then in eighteen sheets with Flanders surveyed in 1746–47 and the Seine triangulation begun in 1747) appeared around 1747. It too exists in several states, the earliest of which does not reflect the triangulation of the Seine begun in 1747. This large map was designed to accompany the report on triangulation operations announced by Cassini III in 1744 but was not published until 1783, as *Description géométrique de la France*. This late work contained only the one-sheet *Nouvelle carte*.

Konvitz rightly thinks that the map elaborated by the Cassinis in the second half of the eighteenth century, the 182-sheet *Carte de France*, was not the obligatory consequence of the general triangulation (or the *Nouvelle carte*), and that the *Carte de France*'s scientific value was less significant than the general triangulation (Konvitz 1982). This view is confirmed by the silence of the *Journal des savans* in 1756–57 upon the publication of the first sheets of the *Carte de France*. The work of the Académie des sciences encouraged the production of geometric maps in several parts of the realm. Collaborators in the general triangulation, such as abbé Réginald Outhier and Delagrive, learned from making their own regional maps (dioceses of Bayeux and Sens; environs of Paris). However, Chevalier had already distinguished himself in cartography before entering the Académie des sciences, where he had presented in 1707 a cartographic method less burdensome than triangulation (see fig. 816). Marc-Pierre de Voyer de Paulmy, comte d'Argenson, minister of war from 1743 to 1757, was very concerned with the exactitude of military maps, and therefore demanded that they be based on triangulation. In the second half of the eighteenth century, as *ingénieurs militaires* became experts on triangulation, they used and checked the work of the members of the Académie and complained about the lack of access to the original detailed calculations (Pelletier 2013, 116, 127–29).

On 7 July 1747, Louis XV, impressed by the fidelity of Cassini III's maps of the Flanders campaign to the terrain itself, including troop positions and topography, decided to have Cassini III prepare a map of his realm (Cassini III 1775, 147–48), variously called the *Carte de France*, *Carte de Cassini*, and, in the introduction accompanying the first sheet in 1756, the *Carte générale et particulière de la France*. The geometric character of the future map was often praised by its designer, who paid great attention to the orthography of place-names and the correct positioning of places (Cassini III [1756], 9). The *ingénieur* responsible for the surveys conveyed notebooks of calculations to the Paris Observatory, including the measures of angles used to calculate the sides of triangles, lists of toponyms, and sketch maps of the topography (Cassini III [1756], 7–10). These documents served as a base for the first drafts. The verifying *ingénieur* would return to the site and submit the draft maps to a local seigneur or priest. Cassini III characterized the division of labor thus: "The geometric operations belong to us; the rendering of terrain [and] the orthography of names are the work of the seigneurs and local priests; the *ingénieurs* present the maps to them, profit from their comments, work under their orders, and execute in their presence the correction of the map, which we publish only when it is accompanied by certificates" (Cassini III [1757], 2). Tables accompanying each sheet listed places "described geometrically": they gave their distances to the meridian of the Paris Observatory and to its perpendicular. The projection of the *Carte de France*, a transverse cylindrical system, was based upon the two principal axes of the general triangulation (the meridian of the observatory and its perpendicular). The tables confirmed the principal function of the map as a foundation for other maps and other types of projects.

Between 1748 and 1755 the work of the *ingénieurs* (numbering eight in 1750 and thirteen in 1755) initially concentrated on complements to the general triangulation. Cassini III trained the personnel, essentially geometers, and organized the operations. At the end of 1755, however, the new *contrôleur général*, Jean Moreau de Séchelles, was trying to reduce the court's expenses and asked Cassini III to interrupt the surveys. As the king did not oppose this decision, Cassini III created a society in June 1756 to ensure financing for the enterprise under conditions approved by the Conseil du Roi at Compiègne on 10 August 1756 (Pelletier 2007, 8). One of the society's first decisions was to request financial contributions from the provinces that had sought the survey of their territories. The *Carte de France* thus received support from three principal sources: the associates who paid membership fees for a limited time; the provincial governments; and sales, which included subscriptions, block sales of all published sheets, and sale of individual sheets, which were less substantial than anticipated (Pelletier 2013, 166–77, 252–55). The contract of association confirmed the society's links with both the Académie des sciences and the Ponts et Chaussées.

The challenges encountered by the enterprise were varied and numerous: training and maintaining quality teams of *ingénieurs*; achieving homogeneous quality in surveying; dealing with financial shortfalls; maintaining good relationships with the provinces, which might criticize the *ingénieur*'s works; recruiting quality engravers; and selling a map, whose 182 sheets formed regular rectangles that reflected a geometric spirit also developed by the *ingénieurs* of the Ponts et Chaussées (fig. 139). This form was badly adapted for some map uses, such as administrative ones requiring a clear perception of internal divisions. Also, a user might be inconvenienced when a place of particular interest was located at the edge of a sheet, requiring the purchase of other sheets to acquire a sense of context (Pelletier 2013, 239).

The surveys for the *Carte de France* were completed

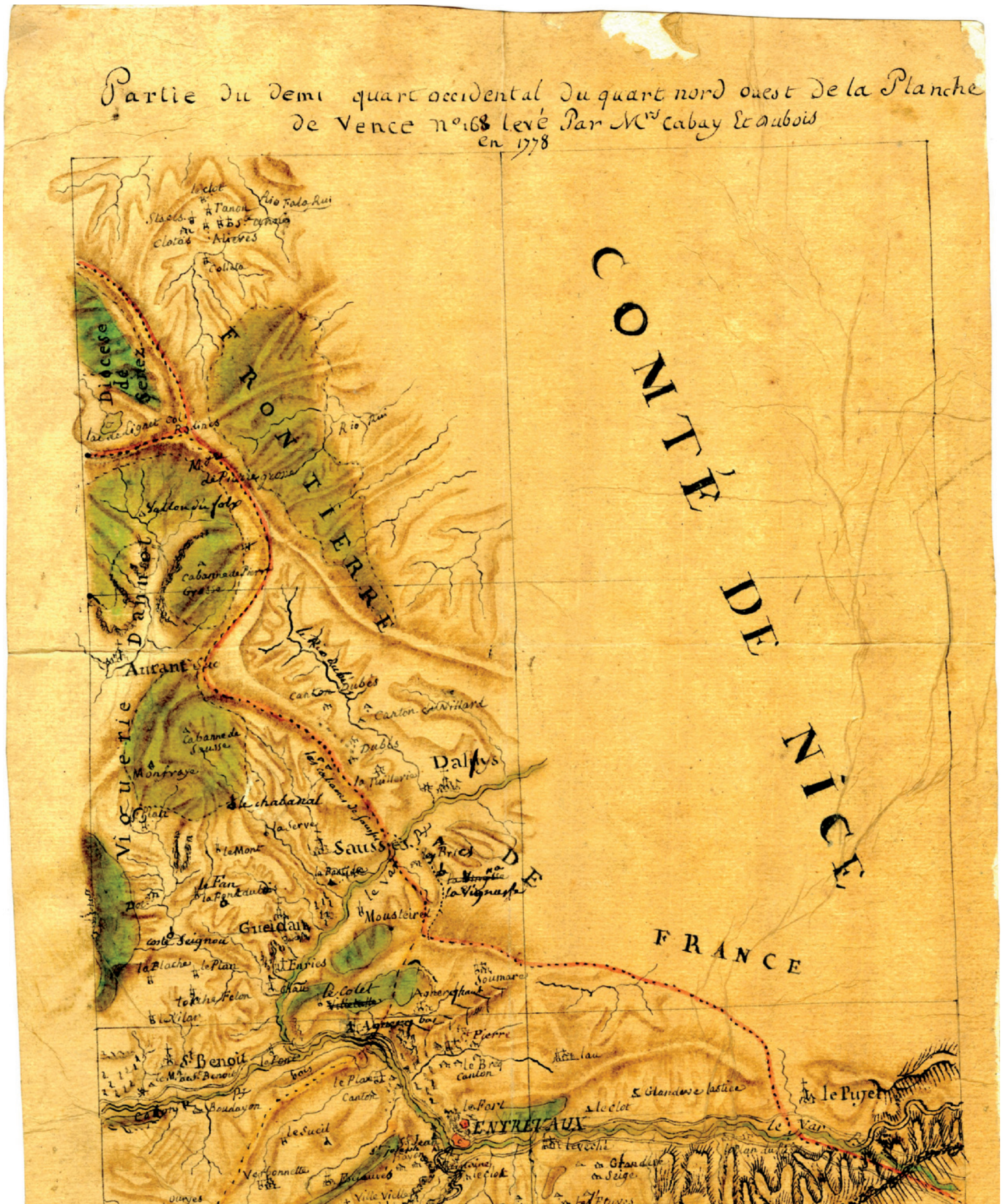

FIG. 139. CABAY AND DUBOIS, ENGINEERS OF CASSINI III, "PARTIE DU DEMI QUART OCCIDENTAL DU QUART NORD OUEST DE LA PLANCHE DE VENCE N^{O} 168," SURVEYED IN 1778. Manuscript draft. Sheet number 168 of the *Carte générale et particulière de la France*, surveyed in 1778–80. The draft outlines the boundary between France and the *comté* of Nice.

Size of the original: 32 × 25 cm. Image courtesy of the Cartothèque, Institut géographique national, Saint-Mandé (Archives de la carte de Cassini).

in 1790, so they were used in the creation of the *départements*, new administrative divisions of France established by the revolutionary government in 1789–90. This creation anticipated the absolute necessity to visualize France's new administrative structures. In fact, a competing enterprise captured this promising market: the *Atlas national*, published by Pierre Dumez and Pierre-Grégoire Chanlaire from 1790 to 1794 (with new editions in the nineteenth century), with a large format including maps at a scale of 1:260,000 that were clear and exact. Nonetheless, the one-quarter reduction of the *Carte de France* (1:345,600), prepared by Louis Capitaine in 1789 with administrative boundaries added the following year, held its own. This reduced version of the *Carte de France* was acquired by the Dépôt de la Guerre in 1815 to be enlarged beyond the Rhine and the Alps.

The other event marking the revolutionary epoch was the complete transfer of the *Carte de France* to the Dépôt de la Guerre in September 1793: copperplates and print runs—1,351 finished sheets and 1,106 proofs—as well as 400 original designs, 50,000 copies of tables, 60 volumes of observations for construction of the large triangles, 400 volumes of observations carried out by the *ingénieurs*, 600 notebooks of calculations, and 500 notebooks listing communes (Cassini IV 1810, 132–34). Henceforth, diffusion of the map was controlled by the army, which between 1803 and 1812 undertook updating the road network, which had been greatly transformed during the eighteenth century (fig. 140). The

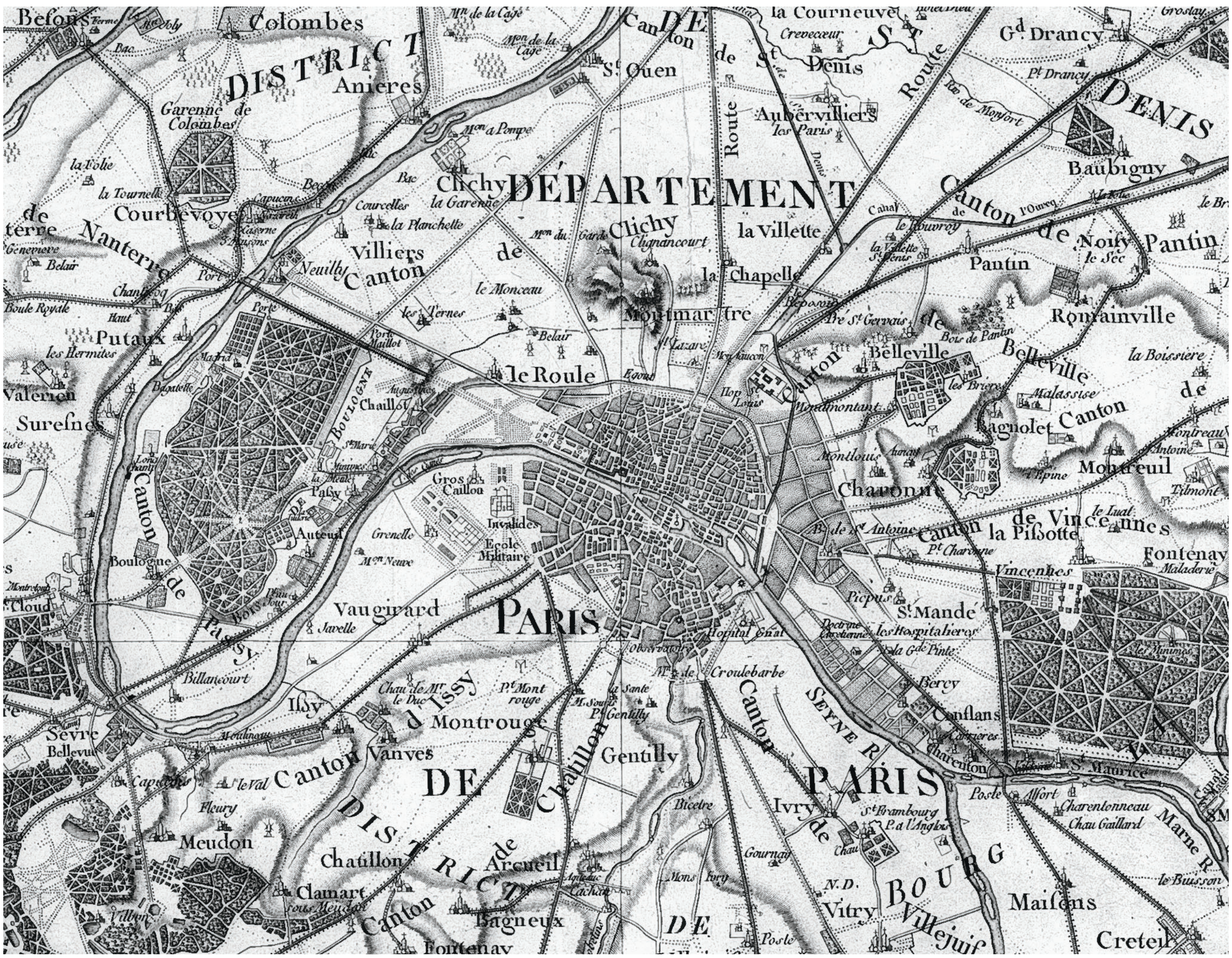

FIG. 140. DETAIL FROM THE PLATE OF PARIS, SHEET NUMBER 1 OF THE *CARTE GÉNÉRALE ET PARTICULIÈRE DE LA FRANCE*, SURVEYED IN 1749–55. New edition around 1803 of the sheet renumbered 7 H. The new edition includes the roads and canals created in the second half of the eighteenth century. Demarcation of the borders of the *département* of Paris has been added, together with the districts composing it, which were suppressed in the year III (1794–95). Size of the entire original: 59.5 × 92.0 cm; size of detail: ca. 17 × 22 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge CC 707 [7 H]).

sheets of this new edition of the *Carte de France* also bore two scales, one in toises and the other in meters.

The military did not fail to draw attention to the shortcomings of the Cassinis' map, including the weak topographic depiction—not a primary objective for Cassini III—errors in positions of certain localities, difficulties in calculating longitudes ignored by the map, and the worn condition of the copperplates. In 1807, Emperor Napoleon I launched the great enterprise of the cadastre that in principle involved more than one hundred million parcels of land. It was an endeavor that the new *Carte de France* could not ignore, as shown by the 14 October 1816 report of Colonel Simon-Pierre Brossier and Commandant Maxime-Auguste Denaix: *Projet d'une carte topographique militaire de la France*.

Devised as a geometric map and accepted, not without criticisms, as a topographic one, even though it did not include any elevation measurements or representation of secondary roads, the Cassinis' *Carte de France* had a very long life. It would be replaced by a true topographic map with elevations and standardized hachures for the relief representation, but that map, the carte de l'État-Major, begun in 1818 (first proofs), would not be completed until 1880 (final printing).

MONIQUE PELLETIER

SEE ALSO: Academies of Science: Académie des sciences (Academy of Sciences; France); Administrative Cartography: France; Cassini Family; Projections: Topographical Survey Plans; Revolution, French; Topographical Surveying: France

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Cartographic Practice, Modes of. See Modes of Cartographic Practice

Cartouche. The presence of cartouches on both printed and manuscript maps and globes was not a novelty in 1650 (Welu 1987). For a century or more, Italian and Flemish geographers and cartographic editors, followed by the Dutch, customarily added various decorative elements to their maps, including iconographic vignettes, historiated frames, cartouches, and color. Thus the cartouche may be considered as one of the "places" on the map that articulated the map's cognitive scope. As both a connector and a catalyst, the cartouche played a role in the circulation of social and cultural values and imaginary spaces connected to the construction of the visual culture of its epoch. To consider the map in conjunction with its cartouches is thus to understand the map fully as a "cultural text" (Clarke 1988).

The diverse definitions of "cartouche" found in the dictionaries and manuals of the period correspond to that given in Antoine Furetière's *Dictionaire universel* (1690): "it is a card in the shape of a cylinder or scroll or its representation, for which the sculpture and the engraving make diverse ornaments, in the middle of which is placed some inscription or device. The titles of geographical maps are written in the *cartouches*, very much historiated."

The cartouche is therefore an entirely decorative element, an ornament that belongs to the domain of architecture, sculpture, and engraving. As a noncartographic element in mapmaking, the cartouche developed as an imagistic ensemble of narrative, description, and symbols appropriate to the territory represented by the map. For its function on a map, the cartouche may be considered equivalent to the pointer (*admoniteur*) in a painting by drawing attention to the subject of the map and orienting its reading (Alberti 1966, 78). The cartouche introduces, shows, recalls, and alerts: in other words, it determines (or tries to determine) a priori the inter-

FIG. 141. CARTOUCHE AS A POINTER. From Nicolas de Fer, *L'Amerique meridionale et septentrionale*, 1727. Size of the entire original: 46.5 × 60.2 cm; size of detail: ca. 11 × 20 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Maps 2-B-1727 Fe).

pretive framework. The pointer is sometimes shown directly in the cartouche (fig. 141).

Moreover, the cartouche functions also as a container, like a frame, whose interior space is usually filled with a title, a device, an inscription, a coat of arms. The cartouche is the place that gathers "titles, explanations, notes necessary for the understanding of each map" (contract between Philippe Buache and the États du Languedoc, quoted in Dainville 1964, 64). As a hollow space, it envelops a central area in which a text announces the map's contents, which are anticipated by the reader. In 1691 the *Mercure Galant* (no. 7) announced a map of the Piedmont (*Carte du Piemont et du Monferrat,* 1691) by le Père Placide, *géographe du roi,* containing "ten cartouches which not only serve just as ornaments, but which are also tables that give a general idea of the regions in a few words and in a very methodical manner" (169–70).

Sometimes the cartouche contains more than the simple identifying words ("Here is Italy . . ."); it may present a historical account of the territories mapped, describe the regions, and give the measurement scales. Finally, it provides the political identity of the place as well as its possessor. In addition, the title in the cartouche can equally proclaim property rights, thus reverberating with the themes of legitimacy and law.

Even though the principal reason for the presence of the cartouche is to aid the reading and comprehension of the map, evoking the territory represented by the map, the cartouche also responds to a more societal function: it contains the name of the person to whom the map is dedicated or addressed. "One calls the cartouche the design that one places at the bottom of plans and geographical maps and which serves to contain the title or the heraldry of the person to whom the map is presented. These cartouches are likely to be decorated with the attributes and allegories that ought to relate to the person being presented with these designs or to the subjects of the designs" (Blondel 1752).

In addition to the title and the contents of the map, the cartouche also may contain the names of the author or editor and the dedicatee. Thus the cartouche becomes a place of legitimization and insertion of cartography into the network of sociability. In describing the cartographic productions of Alexis-Hubert Jaillot, Christine M. Petto has shown how the cartouche is inscribed into a social relationship between the author or editor and the dedicatee, which was completely characteristic of French society during the Ancien Régime: that of patronage (Petto 2007). The importance of the practice of dedication, central to the economy of patronage, is well known: it obliged the patron (the dedicatee) to offer protection, employment, or remuneration in exchange

FIG. 142. CARTOUCHE AS AN AFFIRMATION OF POWER OVER TERRITORY. From Guillaume Sanson, *Les provinces des Pays-Bas catholiques* (Paris: Jaillot/Mortier, 1691).
Size of the entire original: 52.1 × 84.9 cm; size of detail: ca. 16.5 × 26.0 cm. Image courtesy of the Beinecke Rare Book and Manuscript Library, Yale University, New Haven.

for a book or a map, dedicated, offered, and accepted. The author or editor was thus obliged to manifest the glory of the patron (Pedley 2005, 83–84).

Of course, the editors of maps and globes developed this rhetoric of glory and symbolic power toward a monarch (in France, the elements at work in the "fabrication of Louis XIV," to use the phrase of Peter Burke, are well known), but similar language was also used for other levels of political authority, including a prince or dauphin, ministers and grand officers of state, ecclesiastical personnel, municipal authorities, landed gentry, and local aristocracy. The diversity of patrons does not suggest a fundamental rupture in the rhetorical register adopted by the author of the dedication addressed to his patron. To whatever level of authority the map was presented, the dedication was designed to manifest the positive effects of the exercise of this authority, independent of scale.

The discourse or meanings of the cartouche may be classified into three principal categories, which are not mutually exclusive: power and possession, ethnogeography, and arts and civilization. A single cartouche may, in effect, simultaneously develop several levels of different meaning.

The discourse of power, or, as has often been written, of possession or claim of a territory, uses the cartouche like a signature, the mark or imprint of the proprietor and their wishes for a region (fig. 142). This discourse plays out on two levels, sometimes combined: symbolic control and real control. Cartouches employ various strategies for these levels of meaning, including moral or political allegory, heraldry, the recitation of the foundation or genealogical heritage of a territory or of the claimant, and historic events. These affirmations of power over the territory represented by the map often resonate with the transfer of authority or situations of conflict, as has been shown in the subjects of cartouches that ornament maps produced at the moment of the American Revolutionary War or other period of conflict (Clarke 1988; Pedley 2008; Petto 2009). However, the discourse of the cartouche is not limited in a simplistic way to this first level of power. The hermeneutic richness of the cartouche speaks to its capacity to vary the levels of meaning and to connect them.

The second discourse employed by cartouches on globes and maps is that of ethnogeography, which develops the rhetorical mode of visual evidence. The cartouche elicits the effect of reality by showing the region and its visual "truth" by the presence of iconographic vignettes representing the natural resources of the region, its flora and fauna, population and customs, practices and rituals, and mode of dress (fig. 143).

Evidence exists of requests for mapmakers to embellish any heraldry on the map with "geniuses or allegorical figures and appropriate attributes that show the productions of the earth, the natural history, and the commerce of the different cantons, to which one will add what one can concerning particular ancient and modern monuments" (contract between Buache and États du Languedoc, 1748, quoted in Dainville 1964, 64). These discourses or levels of meaning support the hypothesis that the cartouche embodies the descriptive

FIG. 143. CARTOUCHE INCORPORATING THE NATURAL HISTORY OF A REGION. From Thomas Kitchin, *A Map of South America,* 1787, in Robert Sayer, *A General Atlas, Describing the Whole Universe* (London: Robert Sayer, 1790), 35.

Size of the entire original: 50 × 118 cm; size of detail: ca. 38 × 41 cm. Image courtesy of the David Rumsey Map Collection, David Rumsey Map Center, Stanford Libraries.

or chorographic aspect of the map itself, at the same time as the map loses this dimension from its own cartographic contents. As the cartouche took on the functions of the historiated frame, typical of seventeenth-century Flemish and Dutch cartography, this extended decoration gradually disappeared from the so-called scientific cartography of the eighteenth century, though it persisted in the form of vignettes surrounding the map in the productions of the German publishing houses of Homann Heirs and Matthäus Seutter (Diefenbacher, Heinz, and Bach-Damaskinos 2002; Ritter 2001).

A third level of discourse is that of the arts, sciences, and civilization. These were expressed with allegorical representations, both moral and philosophical (the four elements, the Bible, the four parts of the world); by scientific instruments, more precisely by geographical and astronomical instruments; and by portraits. Such cartouches assembled evidence for an image of not just the terrestrial world, but also of an ordered cosmos.

There does seem to be a correlation between different types of discourse and different types of maps. The small scale of a *mappemonde*, globe, or universal atlas employed cartouches filled with philosophical iconography. Similarly, allegories of power and control operated at the medium scale of country and regional maps, just as the heraldry and genealogical display emphasized the ownership in large-scale property maps. Within the manuscript traditions of large-scale military mapping, land surveying, and geodetic mapping, the iconographic use of images of the tools of the observer—measuring rod, chains, poles, plane table, compasses, theodolites, telescopes—embellished the map. As representations of the instruments of science, they highlighted the map's authority in its reliance on measurement and observation and were designed to increase the reader's trust in the veracity of the map. These instruments were often shown in action in cartouches, deployed by surveyors or by the ever-present putti who made their use seem both easy and perhaps even divinely inspired (Heilbron 2000) (fig. 144).

FIG. 144. INSTRUMENTS OF SCIENCE AND CIVILIZATION WITHIN A CARTOUCHE. Title page from Claude Buy de Mornas, *Atlas méthodique et élémentaire de géographie et d'histoire* (Paris: Buy de Mornas and Desnos, 1761), vol. 1, folio oblong.

Size of the original: ca. 32.0 × 47.5 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

The prescriptive character of Blondel's text, cited above (images that "ought to relate"), signals that the cartouche is subject to another tension. Because it is simultaneously the key for reading the map itself and a decorative ornament (carrying signs and explanations that are not necessarily cartographic), the cartouche has two sometimes contradictory goals: knowledge and the pleasure of design and image.

The "moment" of the creation of the cartouche within the process of creating the map has been described in numerous ways. The cartouche is usually added at the end of the process of creating the contents of the map itself. On a manuscript map, the cartouche was usually designed and executed by the author of the map, thereby displaying the artistic skills of the creator and the rhetorical devices aimed at its audience, for example, in the trompe l'oeil effects employed on the maps created for the prize competitions of the École des Ponts et Chaussées (see fig. 631). On printed maps, the cartouche was usually added to the map after the map proper had been engraved. It was often designed by an artist, not the creator of the map, and engraved either by the same artist or another engraver who specialized in this genre of work (cartouches were very often etched, whereas maps themselves were mostly engraved with the burin), at the order of the editor (or publisher) or the mapmaker. For example, the maps of Nicolas Sanson published by Jaillot were engraved by Robert Cordier while the cartouches were entrusted to François Chauveau. Thus the cartouche is very precisely the parergon of the map: a supplement, an ornament. "One has not yet completed the coloring of a design," wrote Henri Gautier, "until one has tried to decorate it with a border or a lovely cartouche" (1708, 100).

The cartouche embodies a tension, at once graphic and professional, for the creators of maps. Since the cartouche was designed, according to the vocabulary of the authors of the epoch, to render the map more beautiful and agreeable, it reintroduced the dimension of the spectacle, both iconographic and theatrical, into cartographic practice at a moment when, quite rightly, geographers were attempting to separate themselves from the mere imagers, in a desire to broadcast their special competencies in scientific milieus. Pierre Duval reaffirmed the necessity for geographers to check and correct the work of mere illuminators who tended to trace the borders of countries on a whim or overload maps with "useless and superfluous names" (Duval 1672, 59–60). Inasmuch as it was an ornament, the cartouche represented a decorative danger for "geographical truth"; certain principles had to be adhered to by the designer of a cartouche in order to ensure that the map was not simply an amusement, but an instructive instrument.

The identification of designers and engravers of cartographic cartouches, as well as the analysis of their involvement in the process of printed mapmaking, constitutes a field open for scholarly inquiry. When cartouches are signed, they provide information on both the designer (*inv[enit]* or *del[lineavit])* and engraver (*sc[ulpsit]* or *fe[cit])*. In Paris, one could profitably research the work of Chauveau, a prolific illustrator and engraver whose cartouches adorn the maps of Sanson published by Jaillot (fig. 145). Similarly rewarding would be a study of the work of Pierre-Philippe Choffard, who, as one of the principal Paris decorative engravers of the eighteenth century, designed and engraved many of the rococo cartouches of Jean Lattré's *Atlas moderne* (1762) and for maps of other geographers, such as Jean-Baptiste Bourguignon d'Anville and Jacques-Nicolas Bellin.

FIG. 145. GLORY AND RENOWN DEPICTED IN A CARTOUCHE. François Chauveau, cartouche for the *Provinces-Unies des Pays-Bas* by Guillaume Sanson, published by Jaillot, 1673.
Size of the entire original: 55.6 × 86.7 cm; size of detail: ca. 24.5 × 25.0 cm. Image courtesy of the James Marshall and Marie-Louis Osborn Collection, Beinecke Rare Book and Manuscript Library, Yale University, New Haven.

Of similar benefit would be a fuller understanding of the role of the artist Hubert-François Gravelot in the design of cartouches for his brother, the geographer d'Anville, and of Gravelot's association with engravers Jean-Baptiste Delafosse and Thomas Major in the completion of these cartouches. Other names equally merit deeper investigation from the point of view of their relationship with the map trade: Jean Le Pautre, Pierre-Gabriel Berthault, Clément-Pierre Marillier, the sisters Elizabeth Haussard and Marie Catherine Haussard, and the well-known Charles-Nicolas Cochin, to name just a

FIG. 146. CLÉMENT-PIERRE MARILLIER, CARTOUCHE. Marillier signed as the designer of the cartouche (lower left) for *l'Amérique méridionale,* by Jean Janvier in *Atlas moderne, ou Collection de cartes sur toutes les parties du globe par plusieurs auteurs* (Paris: Lattré et Delalain, 1762), map no. 33. Size of the entire original: 30.5 × 44.0 cm; size of detail: ca. 17 × 15 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Atl 1762 La).

few in the Paris market (fig. 146). In Germany, the rich cartouches and allegorical vignettes on the maps from the Seutter publishing house were signed by specific artists: Martin Gottfried Crophius, Abraham Drentwett, Melchior Rhein, and Gottfried Rogg (Ritter 2001, 130). While the role of cartouche designer and engraver in other national contexts has yet to be fully explored, preliminary work has been done in the German and Dutch markets (Bosters et al. 1989; Van Egmond 2009; Diefenbacher, Heinz, and Bach-Damaskinos 2002; Ritter 2001).

Even a rapid overview of the milieu of map design, engraving, and trade in Enlightenment Paris reveals that at the level of professional practice, the work of designers and engravers of cartographic cartouches cannot be reduced to a single activity. Most of them were deeply integrated in the world of the printed book for which they designed and engraved title pages, frontispieces, decorative bands, *culs-de-lampe*, vignettes, trophies, and medallions. Many of them published collections of engravings of decorative ornaments for use in interior decoration, architecture, or furniture. The collections of Juste-Aurèle Meissonnier in the *Livre d'ornemens inventés & dessines* (1734) contributed to the diffusion throughout Europe of the rococo style that echoed throughout cartographic cartouche design during the eighteenth century (Bosters et al. 1989, 65–92; Pedley 1992, 65; Heinz 2002, 127, fig. 66).

Thus within the production process for both manuscript and printed maps, the production of cartographic cartouches was linked to the *métiers* (professional trades) of design and engraving, reflecting the relationship between the cartouche and the history of decorative styles in general.

Some commentators (Welu 1987; Andrews 2009; Hedergott 1955) have tried to describe the diversity of cartographic cartouches and account for an evolution in their styles by relying on the large chronological and typological divisions supported by the history of art in general. For the period of the long eighteenth century, the stylistic transformations of cartouches certainly echo the successive phases of mannerism, baroque, and rococo. However, using this lens as a guide would be inaccurate, since it is too general and enclosed in a global comparison that pits art and cartography into two opposing camps. Such an overly generalized interpretive model prevents the historian of cartography from more precisely situating the zones of contact and communication between these two domains (Van Egmond 2009, 258).

To acquire a better sense of the stylistic transformations that cartographic cartouches underwent in the seventeenth and eighteenth centuries, it would be more judicious to place the cartouches at the level of the decorative arts rather than that of the fine arts. In adopting this perspective, two things become apparent. First, there is a relation between the modes of production of cartographic cartouches and the practices and professional norms found in the milieus of the *métiers* of engravers and designers (within the context of commands, prices, and determination of contents). Second, the same designers and engravers involved in cartographic cartouches were also engaged in engravings of allegories, decorative architectural features, designs for furnishings, chimneypieces, and other elements of interior decoration. Cartographic cartouches thus were part of this ensemble of decorative engraving, within which they communicated their message through motifs and content as well as style.

This practical relationship (at the level of the *métiers*, the craftsmen, and the workshops) between the design and the engraving of both cartographic cartouches and decorative objects illustrates the ways in which cartography was inserted in the visual culture and imagination of the period. The cartouche links the cartographic arts and the decorative arts. Through the intermediary of the cartouche, the map becomes a type of "visual furniture" and a decorative yet meaningful element in the decor of the daily environment of its proprietors.

JEAN-MARC BESSE AND NICOLAS VERDIER

SEE ALSO: Art and Design of Maps; Iconography, Ornamentation, and Cartography

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Cassini Family.

CASSINI (I), JEAN-DOMINIQUE
CASSINI (II), JACQUES
CASSINI (III) DE THURY, CÉSAR-FRANÇOIS
CASSINI (IV), JEAN-DOMINIQUE

Cassini (I), Jean-Dominique. Jean-Dominique Cassini (I), a renowned astronomer and the founder of a celebrated dynasty that played an important role in the evolution of French cartography, was born Giovanni (Gian) Domenico Cassini in Perinaldo (Imperia, Italy) on 8 June 1625 into a Sienese family. Between 1639 and 1646, he studied at the Jesuit college in Genoa, where he focused on mathematics, including astronomy. During this time, the Jesuits distinguished between facts and theories in the work of Galileo Galilei; using the former and ignoring the latter, they adopted Tycho Brahe's system of astronomy (Dainville 1940, 212). Cassini I finished his education among the Benedictines of San Fruttuoso (west of Portofino).

Beginning in 1649, with support from the marquis Cornelio Malvasia, senator of Bologna, Cassini I made his first observations from the observatory at Panzano, his patron's villa between Bologna and Modena. In 1650, he was named to the principal chair of astronomy at the University of Bologna, which then rivaled the Jesuit college in Bologna where Giovanni Battista Riccioli was teaching (Bònoli and Braccesi 2001). In 1652–53, Cassini I observed the passage of a comet, and on 21 June 1655 he started using the meridian he had traced on the floor of the Basilica of St. Petronius in Bologna to replace Egnazio Danti's 1575 meridian. This line allowed Cassini I to make numerous observations regarding the obliquity of the ecliptic, the speed of the apparent movement of the sun, and atmospheric refraction (Cassini I 1810, 266–70). In 1664, he resumed his observations of Jupiter (Débarbat and Wilson 1989) and continued with Mars and Venus. He elaborated tables of movements for the satellites of Jupiter, which were intended for calculations of longitude. He published them in Bologna in 1668 and updated them in Paris in 1693. This work, *Ephemerides Bononienses mediceorvm sydervm,* made him famous.

The publication of the *Ephemerides* resulted in the invitation from Louis XIV for Cassini to become a corresponding member of the Académie des sciences. For his first contribution to this august body, Cassini observed an eclipse of the moon in Rome on 26 May 1668 in the palazzo of the ambassador to the Holy See, the future cardinal César d'Estrées. Both these observations and the *Ephemerides* drew the appreciation of abbé Jean Picard. The king's chief minister, Jean-Baptiste Colbert, saw that Cassini could advise on the construction of the Paris Observatory and encouraged the king to invite the Italian scholar to Paris. Through intermediaries, Cardinal d'Estrées successfully negotiated with newly elected Pope Clement IX for Cassini's transfer to Paris, at first meant to be only temporary (Cassini I 1810, 284–87). Cassini I arrived in Paris on 4 April 1669 and was presented to the king, whom he subsequently visited on several occasions. He lived initially in the galeries du Louvre, the royal accommodation for state-supported scholars and artists.

Although Cassini I influenced the construction of what became the Paris Observatory, his relations with the building's architect Claude Perrault, who was directing construction, rapidly deteriorated, due in particular to the astronomer's demand for a huge observation room on the upper floor of the building so that "the sunlight would enter the room through a hole in such a way as to describe on the floor the daily path of the sun's image" (Cassini I 1810, 294). Cassini's criticisms, however, rendered important modifications to the initial project. The king himself intervened, and Perrault succeeded, though not without difficulty, in overcoming the problems raised by the astronomer (Picon 1988, 206–12).

On 4 September 1671 Cassini moved into the Paris Observatory, which became the Cassini residence, and continued the investigations begun in Italy. Daily logs of his observations are still housed in the observatory's library. He benefited from participation in the projects of the Académie des sciences and the possibilities afforded by the new observatory, especially the high-quality instruments used to observe Saturn and its satellites as well as the surface of the moon (from 1671 to 1679), of which he prepared a map presented to the Académie in 1679.

In April 1673, he obtained French citizenship before marrying Geneviève de Laistre, daughter of the lieutenant general of the comté of Clermont-en-Beauvaisis and counselor of the king. The marriage motivated him to purchase the *seigneurie* of Thury and Fillerval near Clermont (Oise), and the château de Fillerval became the family's summer residence. The couple had two sons: Jean-Baptiste (b. 1674) became a soldier and died in 1692; Jacques (Cassini II), followed in his father's footsteps and was of special help when Cassini I became blind in 1710. Cassini I died on 14 September 1712.

On 28 January 1699, Cassini I became the first titleholder of one of the three places designated for astronomers in the Académie, which he directed in 1704 and 1708. In scientific debates, he tended toward the side of tradition: he disputed the theory of the Dane Ole Rømer regarding the speed of light, opposed the principle of universal gravity, and did not adhere completely to Copernican theories.

On 21 May 1682 Cassini I presented to the king and the court a planisphere on a polar projection (7.8 meters in diameter) drawn on the floor of the west tower of the Paris Observatory by Sédileau and Jean-Mathieu de Chazelles (Wolf 1902, 63–65); a reduced version was engraved in 1696 (fig. 147). This work recorded the observations of latitude and longitude carried out all over the world by *académiciens* and their emissaries. Cassini I himself oversaw the training of such travelers as shown in *Les elemens de l'astronomie* (Cassini I 1684, 52–58).

At the request of Colbert to the Académie on 12 June 1683, Cassini supported extending the late Picard's geometric measurements along the meridian of the Paris Observatory. Cassini I's research program, presented on 15 June as the "Projet de la prolongation de la méridienne . . ." (Cassini I 1684), encouraged the Académie not to forget the importance of establishing an accurate map of all of France. With Philippe de La Hire, Cassini I joined the team heading south to carry out measurements. But Colbert's death on 6 September 1683 stopped the project. It was restarted in 1700, suspended in 1701 (having reached Collioure), and completed in 1718 by Jacques (Cassini II), Cassini I's son. In 1701 Cassini I gave an account of the project in which he discussed the shape of the earth: he concluded it was no longer possible to consider it perfectly spherical. In his examination of the length of degrees calculated between Amiens and Collioure, he noted that their measure increased as one moved toward the south (Cassini I 1719, 171–84), a mistake reiterated by his son Jacques in 1713 and 1720.

MONIQUE PELLETIER

SEE ALSO: Celestial Mapping: Enlightenment; Geodetic Surveying: France; Longitude and Latitude; Meridians, Local and Prime; Paris Observatory (France)

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FIG. 147. JACQUES CASSINI (II), *PLANISPHERE TERRESTRE OU SONT MARQUEES LES LONGITUDES DE DIVERS LIEUX DE LA TERRE, PAR LES OBSERVATIONS DES ECLIPSES DES SATELLITES DE IUPITER* (PARIS: IEAN BAPTISTE NOLIN, 1696). Size of the original: 64.5 × 56.5 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 2987 [112]).

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Cassini (II), Jacques. An astronomer and geodesist like his father Cassini I, Jacques Cassini (II) was born on 18 February 1677 at the Paris Observatory. There he began his studies under the direction of Jean-Mathieu de Chazelles. He continued at the Collège Mazarin,

FIG. 148. *CARTE DE FRANCE OU SONT MARQUEZ LES TRIANGLES QUI ONT SERVI A DETERMINER LA MERIDIENE DE PARIS* (1720). Illustration from Cassini II's *De la grandeur et de la figure de la Terre, Suite des Mémoires de l'Académie Royale des Sciences, année 1718* (Paris: Imprimerie Royale, 1720). Size of the original: ca. 24 × 26 cm. Image courtesy of the Division of Rare and Manuscript Collections, Cornell University Library, Ithaca.

where he defended a thesis in mathematics in 1691. In 1694 he entered the Académie des sciences as an astronomy student, became an associate astronomer in 1699, and resident astronomer in 1712 at the death of his father. He directed this institution in 1715, 1726, 1729, 1732, and 1739. In 1710, he married Suzanne-Françoise Charpentier de Charmois, with whom he had three sons—Dominique-Jean, César-François (Cassini III), who would succeed him, and Dominique-Joseph—as well as two daughters, Suzanne-Françoise and Elisabeth-Germaine.

Cassini II traveled to Italy, Flanders, the Low Countries, and England, where he made contacts with Isaac Newton, Edmond Halley, and John Flamsteed. He was admitted to the Royal Society of London, the Königlich Preußische Sozietät der Wissenschaften, and the Accademia delle Scienze dell'Istituto di Bologna. He combined an administrative career with scientific vocation; he became *maître ordinaire* in 1706 at the Chambre des comptes and *conseiller d'État* in 1722. In astronomy, his observations were published in the *Mémoires de l'Académie Royale des Sciences*, and later synthesized in the *Éléments d'astronomie* (Paris, 1740). Cassini, however, did not take a clear stance in the debate on the cosmographic systems. He studied the planets and their satellites and in 1740 published the *Tables astronomiques du soleil, de la lune, des planetes, des étoiles fixes, et des satellites de Jupiter et de Saturne,* based on the Parisian meridian. As he grew older, he gradually abandoned scientific activities, leaving his son, Cassini III, to carry on the family work. He died at Thury, following an accident, on 15 April 1756.

In 1700–1701 Cassini II had joined his father's efforts to measure the meridian southward. The project, interrupted after 1701, was completed under his direction along the Paris-Dunkirk line in 1718. From 1713, Cassini II entered the debate regarding the shape of the earth, opposing Isaac Newton and Christiaan Huygens, who favored the theory of a flattened earth, and supporting instead the hypothesis of an elongated earth, already formulated by the Strasbourg mathematician Johann Caspar Eisenschmidt. To support his views, Cassini II relied on the measurements of Jean Picard for the northern portion of the meridian and his own measurements for the southern portion, establishing his argument in the "Table des degrés méridiens de la Terre" (Cassini II 1739, 198). In 1720 he published *De la grandeur et de la figure de la Terre,* which detailed the measurements of the southern and northern portions of the meridian (fig. 148), allowing him to reaffirm that the earth was elongated toward the poles. Although opposed by Pierre Louis Moreau de Maupertuis, as well as Voltaire, Cassini II received discreet support from Jean-Baptiste Bourguignon d'Anville, who concluded, based on the measurements of longitude available to him as an eminent cartographer, that "the earth is much less extended in its east-west diameter than it is north to south" (d'Anville 1735, 12).

On 1 June 1733, with his sons, his cousin Giacomo Filippo Maraldi, abbé Jean Delagrive, and François Chevalier, Cassini II undertook the measure of the perpendicular to the meridian, a great circle of the sphere, which crossed France from east to west, in order to "know the relationship between degrees of longitude and those of latitude" (Cassini II 1735, 392). This measurement led him to reaffirm the elongated form of the earth for "the degrees of longitude are smaller than in the spherical hypothesis" (Cassini II 1735, 402). The bitterness of these debates encouraged the Académie des sciences to organize two expeditions: one to Peru (1736–44) and the other to the northern end of Gulf of Bothnia (1736–37).

MONIQUE PELLETIER

SEE ALSO: Geodesy and the Size and Shape of the Earth; Geodetic Surveying: (1) Enlightenment, (2) France; Height Measurement: Altimetry

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Grandjean de Fouchy, Jean-Paul. 1762. "Éloge de M. Cassini." *Histoire de l'Académie Royale des Sciences, année 1756:* 134–46.

Cassini (III) de Thury, César-François. Son of Jacques Cassini (II), César-François Cassini (III) de Thury was born in Thury on 17 June 1714. He studied astronomy at the Paris Observatory under the direction of his great uncle Giacomo Filippo Maraldi. He was named adjunct astronomer supernumerary at the Académie des sciences on 12 July 1735, adjunct astronomer on 22 January 1741, associate mechanic on 22 February 1741, and resident astronomer on 25 December 1745. He acted as director of the Académie in 1758, 1767, and 1771. In 1747, he married Charlotte Drouin, daughter of Louis-François Drouin, seigneur de Vandeuil, with whom he had a son, Jean-Dominique, who succeeded him as astronomer, geodesist, and administrator of the *Carte générale et particulière de la France*, as well as a daughter, Françoise-Élisabeth. In 1748 Cassini III was named *maître ordinaire* at the Chambre des comptes as well as *conseiller du roi*. He was also a member of the Royal Society of London and of the Prussian Königliche Akademie der Wissenschaften. His astronomical work was of limited interest, and his efforts to improve the operation of the Paris Observatory had little effect during his lifetime. Nevertheless, in 1771 he became the first titular director of this institution. His principal work was the *Carte générale et* *particulière de la France*, which mobilized all his energies. He died in Paris on 4 September 1784.

Cassini III joined his father in measuring the perpendicular to the meridian of the Observatory in 1733–34. The coasts of France then received priority, and in 1735–36, with Giovanni Domenico Maraldi, son of Giacomo Filippo, who played an important role in completing the general triangulation of France, Cassini III surveyed the Breton coast. In 1737, again with Maraldi, he measured the Cherbourg-Nantes-Bayonne meridian. He added the Bayonne-Antibes perpendicular line the next year. Cassini III wished to determine the shape of the earth "in all its aspects." Having measured the degrees of latitude in the south of France, he planned to measure degrees of longitude by measuring the time it took for sound (an explosion) to travel over a certain distance (Cassini III 1741, 133). After Pierre Louis Moreau de Maupertuis published in 1738 the results of the expedition to the Gulf of Bothnia sponsored by the Académie des sciences, Cassini III started the next year to remeasure the meridian of the Paris Observatory with abbé Nicolas-Louis de La Caille. This measurement led him to reconsider the theory formulated by his father and grandfather. According to his newer calculations, the length of a degree gradually diminished the farther one moved to the south; the earth, therefore, flattened out at the poles (Cassini III 1744, 25).

Cassini III announced the imminent publication of a map in sixteen sheets included in a book in three parts (Cassini III 1749, 559), the pedagogical goals of which were evident, as the four preserved manuscripts show (Manuel-Gismondi 2001). But the publication of the *Description géométrique de la France* was delayed until 1783 because Cassini himself was entrusted with a mission that he had first thought others should complete: the survey of a general and detailed map of the kingdom (Cassini III 1775, 147–48). Previously, his mission had been to continue triangulation from France into Flanders and Brabant (Lemoine-Isabeau 1984, 142) in order to link it to the work of Willebrord Snellius and to support the surveys of the *ingénieurs militaires*. This mission demonstrates how military cartography was developing pari passu with the *Carte générale et particulière de la France* as surveyed by Cassini's *ingénieurs*. But the *ingénieurs militaires* regretted their lack of access to the calculations of the general triangulation kept by Cassini III (Ingénieurs militaires 1776); their need probably explains the publication of the *Description géométrique* (Paris, 1783), which included the calculations.

The operations for the *Carte générale et particulière de la France* did not begin until 1750. "Everything had to be created"; good *ingénieurs* had to be trained, and expenses were higher than expected (Cassini IV 1810, 100–104). The surveys, performed at a scale of 1:86,400, progressed more quickly than the engraving, and this delayed diffusion of the work. At the end of 1755, a letter from the *contrôleur général* (minister of finance) ordered the *ingénieurs* in the countryside to suspend all surveying. Cassini III, distressed by this suspension, began planning in February 1756 for a private society to help resume operations; the society had signed fifty members by mid-July 1756. Soon thereafter, with two sheets prepared and printed (see fig. 140), Cassini III presented one of them, a sheet of Beauvais, to Louis XV at his summer retreat at Compiègne. Although the monarch admired the map, he did not wish to oppose his finance minister. Three days later Cassini III submitted to the king his project for a private association to support the execution of the map, which the king approved the following day. The fifty original associates were soon joined by forty-two others (Cassini IV 1810, 108–10; Pelletier 2007a, 8).

Cassini III also navigated skillfully between the desire of the monarch and his administration for centralization and the desire of the provinces to promote themselves by maps and histories (Pelletier 2007a, 2007b). His primary objective for his *ingénieurs* was to determine the precise positions of places by the mean of angular measurements, recorded in registers used for constructing the draft maps (Pelletier 2013, 131–58). These initial measurements were verified in the field by other *ingénieurs* who submitted them to local seigneurs and priests in order to check topography and toponymy (geometry remained the *ingénieur*'s domain). The map was nearly finished when the Revolution broke out in 1789.

The principal accomplishment of Cassini III was "to have, for the greatest benefit of geography, realized the transition from geodesy to topography, as his ancestors had accomplished the passage from astronomy to geodesy" using "the direct and global action of the observer whose vision encompassed all of a region, however extended it might be" (Drapeyron 1896, 250).

MONIQUE PELLETIER

SEE ALSO: *Carte de France*; Geodesy and the Size and Shape of the Earth; Geodetic Surveying: France; Paris Observatory (France); Projections: Topographical Survey Plans; Topographical Surveying: France

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Cassini (IV), Jean-Dominique. Son of César-François Cassini (III) de Thury, Jean-Dominique Cassini (IV) was born in the Paris Observatory on 30 June 1748. After education at the Collège du Plessis and with the Oratorians at Juilly, he studied physics with abbé Jean Antoine Nollet, mathematics with Antoine-René Mauduit, and astronomy at the Observatory with Giovanni Domenico Maraldi and abbé Jean Chappe d'Auteroche. His artistic gifts also developed, as is shown by his *Manuel de l'étranger qui voyage en Italie* (Paris, 1778), which includes eight maps. Adjunct astronomer at the Académie des sciences in 1770, he became associate astronomer in 1785. In 1773, he married Claude-Marie-Louise de La Myre-Mory, with whom he had eight children, three of whom died young. The youngest, Alexandre-Henri-Gabriel, a jurist and a botanist, marked the end of the Cassini dynasty.

At the death of his father in 1784, Cassini IV was named director of the Observatory and continued his father's reforms: restoring buildings, constructing new instruments, and creating a permanent team of young observers. Outraged by the suppression of the Académie des sciences and the confiscation of the *Carte générale et particulière de la France* in August and September 1793, he did not agree with the Revolutionary reforms and was forced to leave the Observatory on 4 September 1793. Denounced by the Département de l'Oise, he was arrested in Paris on 14 February 1794 and imprisoned in the convent of English Benedictines. On 5 August he retired to Thury with his children. He refused a position at the Bureau des longitudes, which was created in June 1795 and incorporated the Observatory. The following year, he declined membership in the division of astronomy at the new Institut national, but he reconsidered in 1799. From 1800 to 1818, he presided over the Conseil général de l'Oise. He received pensions and decorations from Napoleon and Louis XVIII, and he died at Thury on 18 October 1845 at age ninety-seven.

Like his ancestors, Cassini IV was preoccupied with the determination of longitude. As the Académie's commissioner for examining marine chronometers, he tested two clocks made by Pierre Le Roy during a voyage to North America and Africa in 1768 (Cassini IV 1770, 115–44). He edited the *Voyage en Californie*, completed by Chappe d'Auteroche in 1769 (Paris, 1772). But his principal task after his father's death was to finish the *Carte générale et particulière de la France,* delayed by critics from the États de Bretagne (Cassini IV 1810, 121–26) and persistent lack of funds. Cassini IV also renewed his father's ambitious project to extend the chain of triangles that covered France to cover all of Europe. In 1787 he participated in the geodetic connection of the observatories at Paris and Greenwich, working with William Roy, Pierre-François-André Méchain, and Adrien-Marie Legendre.

His role in the *Carte générale et particulière de la France* was ended by the Revolution. On 21 September 1793, the Convention nationale ordered that the *Carte générale et particulière de la France* be transported to the Dépôt de la Guerre because the French government considered the map national property issued by the Académie des sciences—an institution that had just been suppressed. Cassini IV fought for his rights as author and director and for those of the society members who had invested in the project. On 16 February 1794, the minister of war proposed indemnities that were confirmed seven years later by the Consulate, but Cassini IV was not reinstated as director and curator of the *Carte générale et particulière de la France*. This struggle and rejection embittered Cassini IV. He refused to participate in the new effort to measure the meridian, and he criticized the excesses of the project as dangerous, expensive, time-wasting, and with the dubious results of a "meter that resembles nothing" (Cassini IV [1823], 78). He recommended a program for the new owners of the *Carte générale et particulière de la France:* to revise the topography and toponymy of some plates as well as angles and distances; to finish the publication of the tables of distances; and to complement the map by publishing a general geographic, physical, and political dictionary of France (Cassini IV 1810, 249–53).

MONIQUE PELLETIER

SEE ALSO: *Carte de France*; Greenwich-Paris Triangulation; Paris Observatory (France); Revolution, French

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Devic, J. F. S. 1851. *Histoire de la vie et des travaux scientifiques et littéraires de J.-D. Cassini IV.* Clermont (Oise): Daix.

Cassini, Giovanni Maria. Giovanni Maria Cassini was born in 1745 in Rome, where he also died, probably in 1824, after a long illness. Little is known of his early training; the earliest documentary evidence from 1769 describes him as a *procuratore* (delegate) in the Roman monastery of the Somaschi Fathers (Grizzuti 1971, 403).

As an engraver, his first signed works were sixty-four plates in Giovanni Battista Passeri's *Picturae Etruscorum in vasculis* (1767–75) and the eighty plates drawn and engraved for the *Nuova raccolta delle megliori vedute antiche, e moderne di Roma* (1775). During the 1770s his ability as a draftsman and engraver established him in the close-knit world of Roman copperplate printing, dominated by Giovanni Battista Piranesi. Although Cassini is often described as the latter's pupil or apprentice, no evidence supports this claim.

Cassini's first cartographic engravings were published in Pier Maria Cermelli's *Carte corografiche, e memorie riguardanti le pietre, le miniere, e i fossili* (1782). In 1790, he engraved the gores for his first terrestrial globe (fig. 149), followed in 1792 by the gores for his celestial globe, created according to "the observations of Sig. Flamsteed and of La Caille" (cartouche). Both works were published by the Calcografia Camerale (Grelle Iusco 1996). The publication of the two globes were steps toward a much more ambitious publishing venture. In 1787 the Calcografia Camerale commissioned Cassini to produce a geographical atlas, promising to pay all the production costs including that of an introductory geographical text. Father Girolamo Pongelli was meant to be the author, but the text mentions only Pietro Bonacorsi, who certainly coordinated the preparation of the maps (Valerio 2005, 74). As the "Introduzione" mentions, this important commission to Cassini served "advantageous purposes of His Excellency the Most Reverend Monsignor D. Fabrizio Russo, General Treasurer," who intended the publication to provide a social and cultural service for the nation, which lacked a modern geographical atlas (Cassini 1792, 21). The *Nuovo atlante geografico universale* was published in three volumes: in 1792 (fifty-five maps), 1797 (seventy maps) and 1801 (fifty-seven maps). The first volume included the previously published terrestrial and celestial globe gores. The "Introduzione" described in detail Cassini's method for preparing the gores using sinusoidal rather than circular curves (Cassini 1792, 7–8), identifying it as that described by Nicolas Bion in 1699 (Valerio 2005, 79–84).

FIG. 149. GIOVANNI MARIA CASSINI, TERRESTRIAL GLOBE GORES, ROME, 1790. Three gores with the title cartouche and the Western Hemisphere.
Size of the original: 49.2 × 32.6 cm. Image courtesy of the Geography and Map Division, Library of Congress, Washington, D.C. (G3201.B71 1790.C3).

Cassini not only produced a thoroughly up-to-date atlas but also identified the sources he used, thus supplying an overview of contemporary cartography. The "Introduzione" mentions a number of important Italian atlases, including the Venetian atlases by Antonio Zatta "created to accompany Zatta's edition of [Anton Friedrich] Büsching's *Geografia,*" and by Francesco Santini, "who made exact copies of the best recent maps" (Cassini 1792, 20).

Cassini also included the cartographic work begun in 1788 by the Sienese printer Vincenzo Pazzini Carli and edited by Bartolomeo Borghi. As to his own work, "he spared himself no effort, diligence, or cost . . . in order to gather wherever possible enlightenment, information, and the best available documents, so that they might contribute to the exactitude and value of the work" (Cassini 1792, 21). Among Cassini's other major cartographic works was his large map of Italy in fifteen sheets, *Carta generale dell' Italia divisa ne' suoi stati e provincie,* published by the Calcografia Camerale (1793).

VLADIMIRO VALERIO

SEE ALSO: Calcografia Camerale (Copperplate Printing Administration; Rome); Map Trade: Italian States

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Cassini Map. See *Carte de France*

Celestial Mapping.

- ENLIGHTENMENT
- DENMARK AND NORWAY
- FRANCE
- GREAT BRITAIN
- ITALIAN STATES
- PORTUGAL
- SPAIN
- SWEDEN-FINLAND

Celestial Mapping in the Enlightenment. By 1650, astronomical enquiry featured well-established traditions of mapping stars within their constellations, elaborating diagrammatic models of the solar system, and constructing naturalistic depictions of the moon, sun, and some of the planets (Friedman Herlihy 2007; Van Gent and Van Helden 2007). This entry considers the continuation of these interrelated practices, together with their reforms, in the Enlightenment. It focuses on the principal works of astronomers but turns, in closing, to the more popular imagery produced for Europe's public. Subsequent entries explore celestial mapping within particular national contexts.

Star maps, which delineated the celestial sphere and the constellations by which the randomly distributed stars were organized and located, were integral to early modern astronomical practice. Determination of the orbits and motions of the sun, moon, planets, and comets required a standard frame of reference, which the fixed stars provided. For example, many seventeenth- and eighteenth-century astronomers mapped the passage of comets across the constellations (fig. 150); conversely, the predicted movement of a planet could be mapped by reference to the stars in order to guide observers in taking new and precise measurements of the planet's mo-

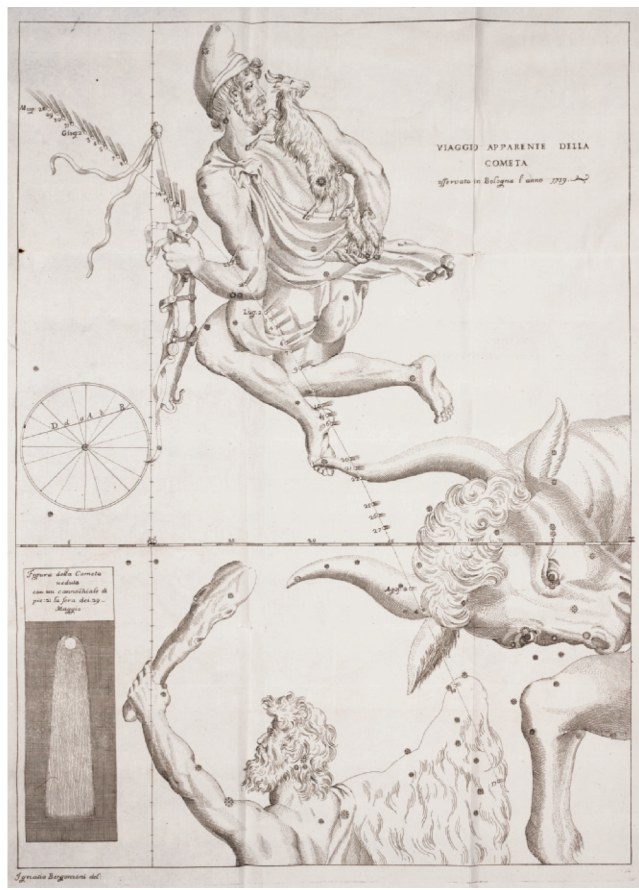


FIG. 150. A COMET MAPPED AGAINST THE STARS. Ignatio Bergonzoni, *Viaggo apparente della cometa osservato in Bologna l'anno 1739*, from Eustachio Zanotti, *La cometa dell'anno MDCCXXXIX* (Bologne, 1739), last page (facing 28). Zanotti, a member of the Accademia delle Scienze dell'Istituto de Bologna, was one of many astronomers who published pamphlets with such maps of the paths of comets. The path of this comet, with its tail steadily diminishing, passes from upper left (28 May), across the constellation Auriga, past the horns of Taurus on the ecliptic (the graduated horizontal line), to bottom right (17 August).
Size of the original: ca. 48.0 × 34.5 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City (Séguier collection, item 5).

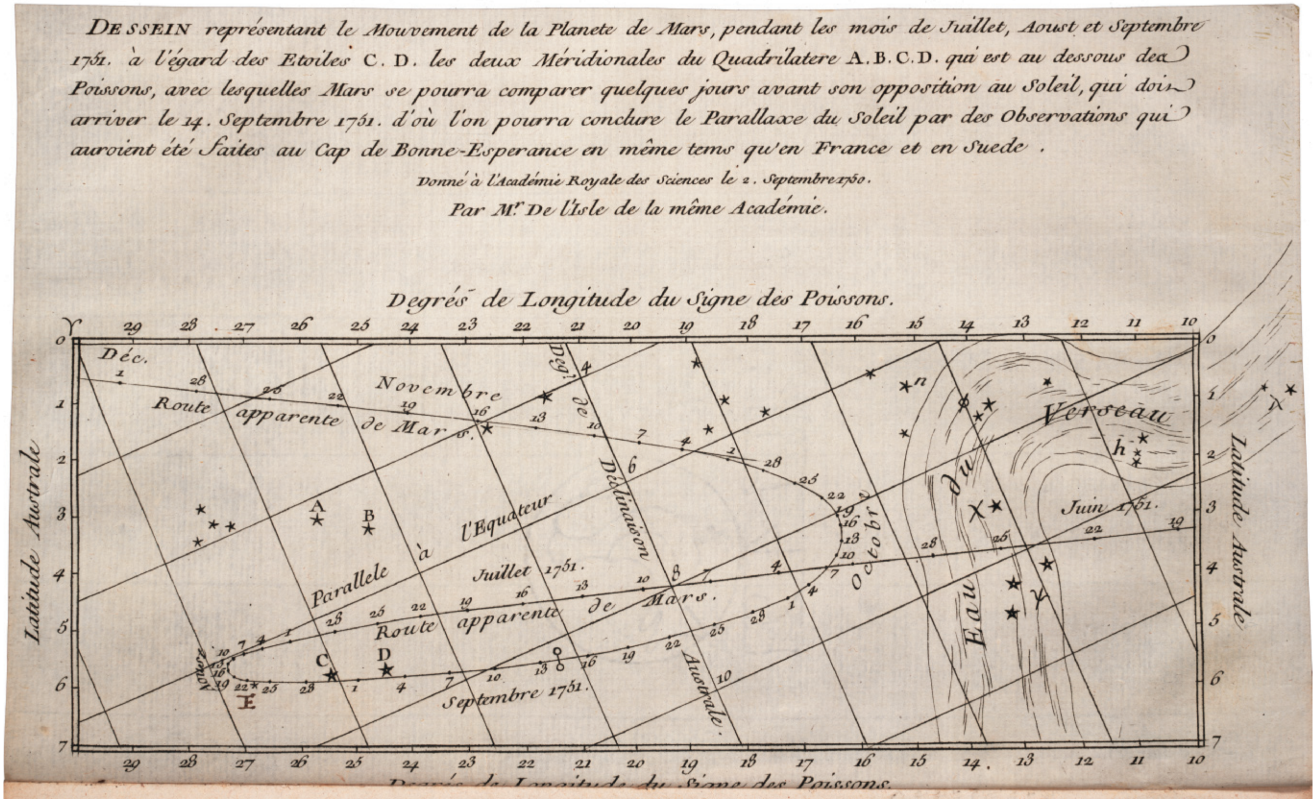


FIG. 151. A PREDICTION OF MARS'S APPARENT RETROGRADE MOTION. Joseph-Nicolas Delisle prepared *Dessein représentant le mouvement de la planete de Mars, pandant les mois de Juillet, Aoust et Septembre 1751* to accompany Nicolas-Louis de La Caille's *Avis aux astronomes* (N.p., 1750), between 25 and 26. La Caille observed Mars from the Cape of Good Hope, from August to October 1751, to determine solar parallax in conjunction with simultaneous observations in France and Sweden; the determination would actually be achieved in the 1760s with worldwide observations of the transit of Venus. Size of the original: 8 × 20 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City (Séguier collection, item 24).

tion (fig. 151). In measuring the momentary position of the moon, a planet, or a comet against the stars, astronomers used their star maps to identify the reference stars and so find the coordinates as listed in star catalogs. A major task for Enlightenment astronomy—indeed, the principal task of the many state-sponsored observatories created after 1650 (Bennett 1992, 1–2)—was therefore the perfection and enlargement of the catalogs together with the preparation of comprehensive star atlases as graphic indexes.

When astronomers argued after 1660 that the problem of determining longitude at sea could be solved by tracking the motion of the moon relative to the fixed stars, they had to accept that the best catalog then available—Johannes Kepler's *Tabulæ Rudolphinæ* (1627), which combined Tycho Brahe's remarkable catalog of about 1,000 stars from ca. 1598 with the classical Ptolemaic catalog and observations of southern stars by Dutch navigators in the 1590s (Dekker 1987)—was simply too imprecise and erroneous for the task. Charles II therefore founded the Royal Observatory at Greenwich in 1675 with the specific goal of creating a large, precise, and accurate stellar catalog. The labors of John Flamsteed, the first astronomer royal, eventually led to the posthumous publication of both his three-volume *Historia coelestis Britannica* (1725)—which presented all his observations, explained the process of their reduction, located 2,935 stars, and correlated them to previous catalogs—and his *Atlas coelestis* (1729) with twenty-seven maps (fig. 152).

The major star atlases of the Enlightenment were all grounded in new and updated star catalogs. All would be copied repeatedly in various British, French, German, Dutch, and Italian publications (Ashworth 2007; Kanas 2012, 151–90). Johannes Bayer had largely based his *Uranometria* (1603), with fifty-one maps, on the work of Tycho and Dutch navigators (Dekker 1987; Friedman Herlihy 2007, 115–16). Bayer's work would not be superseded until Johannes Hevelius in Gdańsk prepared a corrected and expanded catalog of 1,888 stars together with the *Firmamentum Sobiescianum, sive Uranographia,* an atlas with fifty-six maps (fig. 153). The last and greatest product of nontelescopic astronomy, Hevelius's catalog and atlas formed separate volumes of his posthumous *Prodromus astronomiæ* of 1690. But even then, Bayer's atlas continued to be used as the basic reference work in France and Britain, where Hevelius's work remained little known: Flamsteed would design his *Atlas coelestis* in opposition to Bayer's *Uranometria*, and he gave little attention to Hevelius's work. Flamsteed's works would in turn form the foundation of stellar astronomy for the remainder of the eighteenth century (Warner 1979, 18–20, 112–16, 80–82). The complementarity of stellar cataloging and mapping was manifested on those occasions when atlas maps were actually interleaved with the relevant portions of the catalogs. This was the case, for example, with the dedication copy of Hevelius's *Firmamentum Sobiescianum* sent by his widow to Louis XIV (Targosz 1988, 155) and similarly with John Bevis's planned but unpublished "Uranographia Britannica" of about 1750, which had the tables opposite the plates (Ashworth 1981, 72).

The continuing program by the ever-increasing number of observatories to refine stellar locations meant that new and derivative atlas editions often contained new information. The major advances in this regard came with observations made of the southern skies. From the Atlantic island of St. Helena, in 1676–77, Edmond Halley

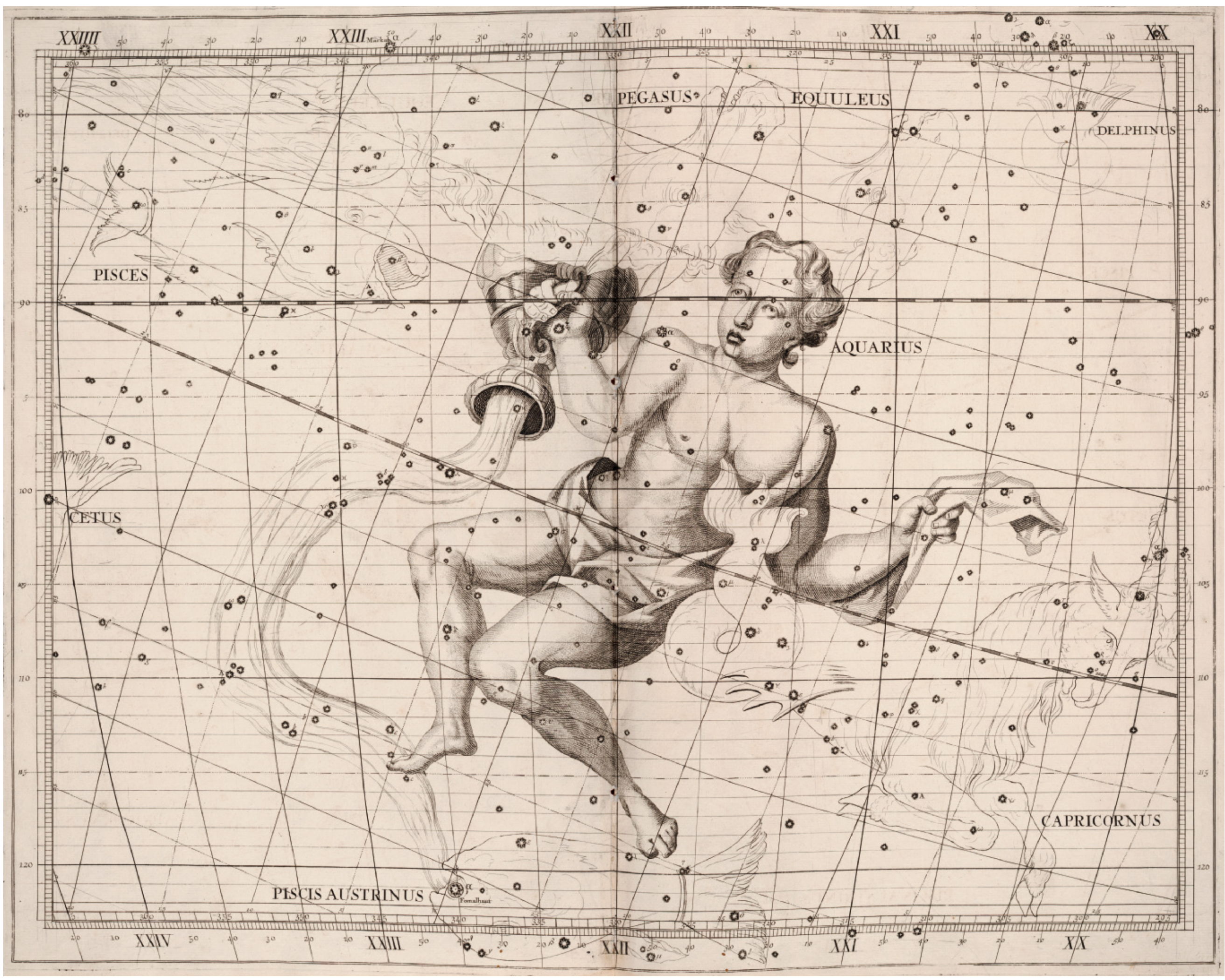


FIG. 152. AQUARIUS, FROM JOHN FLAMSTEED'S *ATLAS COELESTIS* (LONDON, 1729). The heavier graticule, oriented to the graduated horizontal line of the celestial equator, indicates north polar distance (the complement of declination) and right ascension; the lighter graticule, oriented to the graduated diagonal line of the ecliptic, indicates celestial latitude and longitude. Flamsteed labeled each star within the constellation in order of magnitude: α and β Aquarii, for example, are in the shoulders.

Size of the original: 51 × 65 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City.

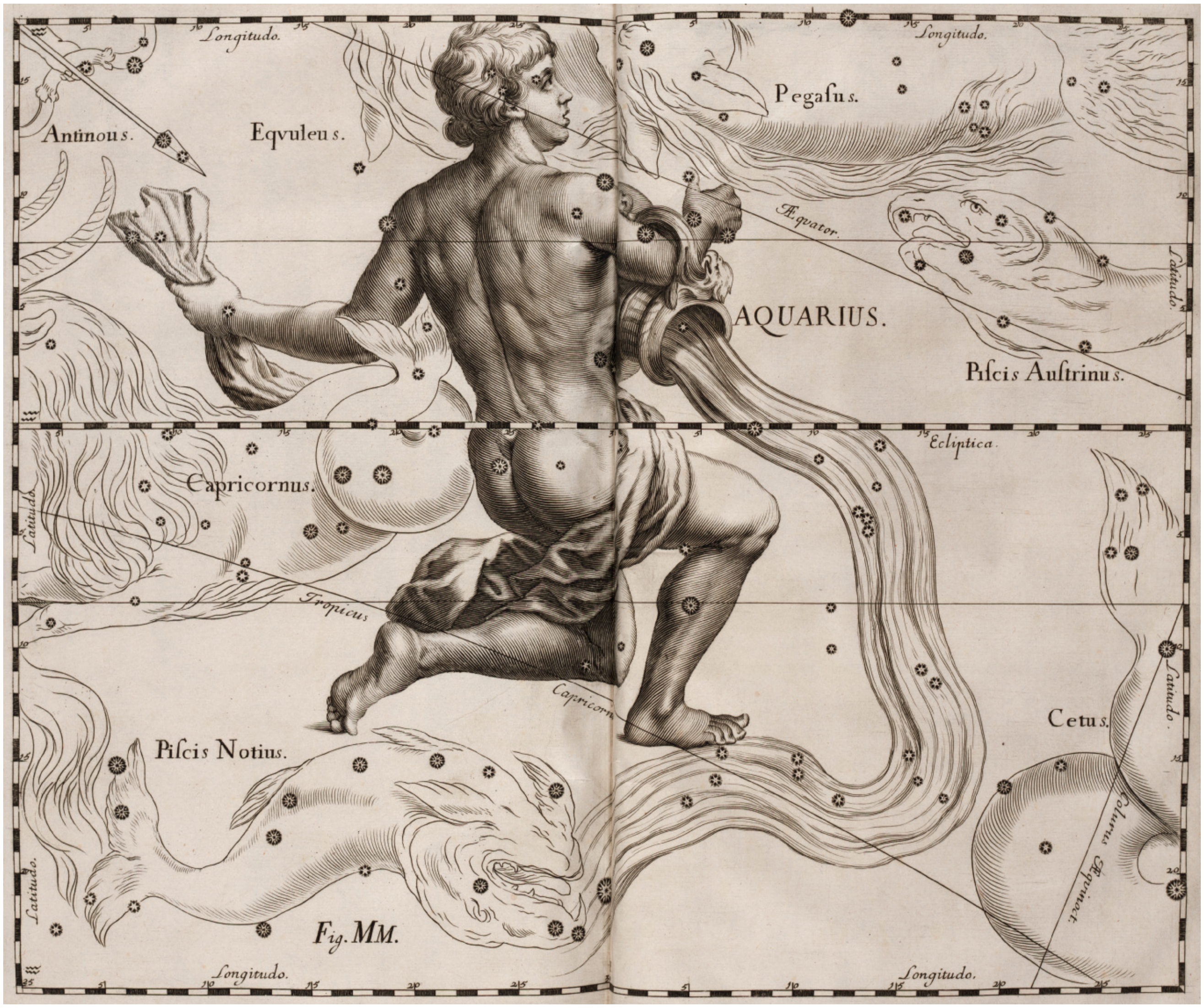


FIG. 153. AQUARIUS, FROM JOHANNES HEVELIUS'S *FIRMAMENTUM SOBIESCIANUM* (GDAŃSK, 1690), FIG. MM. Hevelius copied most of his constellation figures either from Willem Jansz. Blaeu's ca. 1598 celestial globe or from the planispheres inserted in the spandrels of Joan Blaeu's 1648 world wall map. The graduated horizontal line indicates the ecliptic; the thin diagonal lines are the equator and the Tropic of Capricorn. The graduated margins indicate a trapezoidal projection.
Size of the original: 30 × 37 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City.

observed 341 southern stars; his catalog, complete with a map (fig. 154), appeared in 1679. Nicolas-Louis de La Caille prepared a map of the southern sky to accompany his 1763 catalog of 9,800 southern stars, observed from the Cape of Good Hope in 1751–52 (see fig. 165). Persistent astronomical observations led to the updating of Flamsteed's atlas in Paris, as the *Atlas céleste de Flamstéed*, first by the globemaker Jean Fortin in 1776 and then, with further corrections by Joseph-Jérôme Lefrançais de Lalande and Pierre-François-André Méchain, in 1795. In Berlin, Johann Elert Bode also updated the 1776 edition of Flamsteed's atlas, together with a new catalog, in his *Vorstellung der Gestirne* (1782). Finally, Bode combined the work of the eighteenth-century observers into a huge new catalog of 17,240 stars with an accompanying twenty-plate atlas, *Uranographia sive astrorum descriptio* (1801), which represents the culmination of Enlightenment stellar cartography (see fig. 239) (Warner 1979, 107–9, 142–43, 84–85, 34–39).

The increase in the number of known stars—both newly observed southern stars and those visible only with telescopes—led astronomers to create many new constellations to organize and name the new additions to the stellar catalogs, such as the pendulum clock, or

Horologium (see fig. 183). The new figures were designed for many reasons, including recognition of patrons, and other astronomers did not necessarily adopt them. Nonetheless, the number of constellations in use steadily increased from the forty-eight inherited from Ptolemy to the ninety-nine by which Bode organized his *Uranographia* in 1801.

The maps in these star atlases possessed a consistent aesthetic. Each positioned the figures of one or more constellations and their constituent stars—whose sizes on the map were proportional to their relative brightness, or magnitude—within a complex network of lines of latitude and longitude. In particular, the artistry with which the constellations were drawn varied with the skill

FIG. 154. EDMOND HALLEY'S GENERAL MAP OF THE SOUTHERN SKY. The chart appeared in Halley's *Catalogus stellarum australium* (1679) and used an azimuthal stereographic projection centered on the pole of the ecliptic. The radiating straight lines indicate stellar longitude; the circles, centered on the Antarctic celestial pole, indicate declination. Diameter of the original: 46.5 cm. © National Maritime Museum, Greenwich, London. The Image Works.

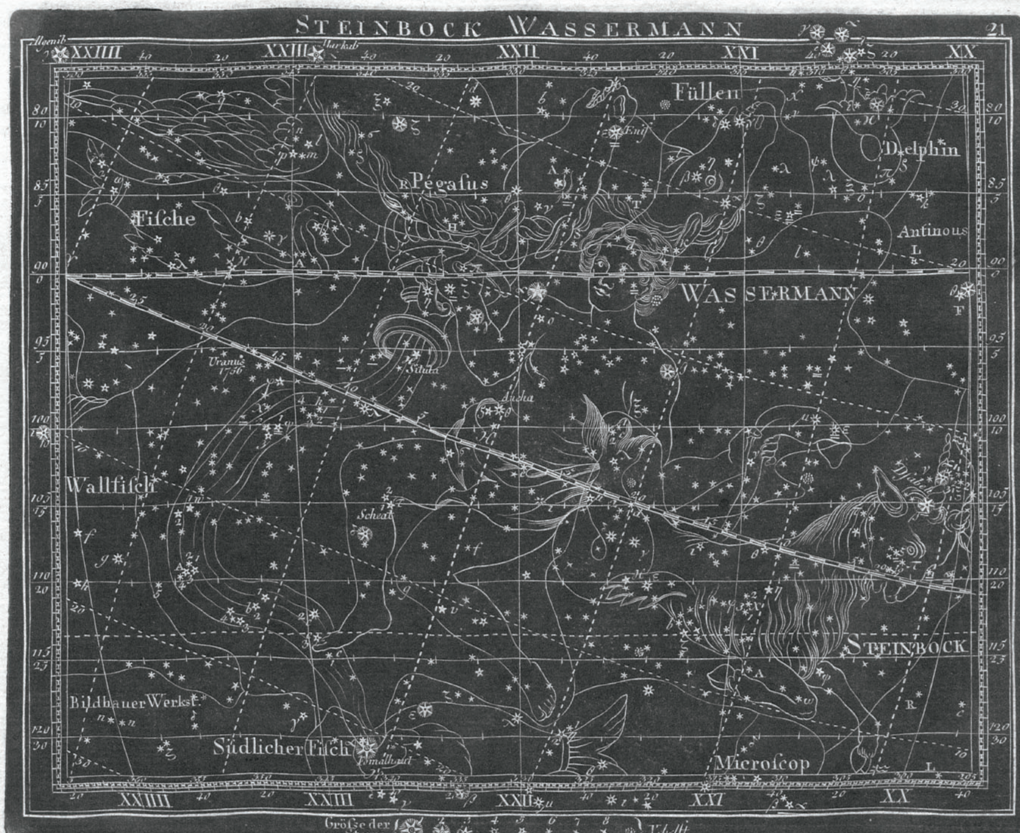
of the draftsmen and engravers who prepared the maps, the models from which the figures were copied, and the prevailing sentiments of decorative style. One evident eighteenth-century trend was the progressive simplification of the constellation figures in response to the steady increase in cataloged stars needing to be portrayed. Furthermore, watercolor was rarely applied to works intended for astronomers but was common for popular works. Overall, the common aesthetic stemmed from the printing of star charts from copperplates: other than the depictions of stars and the constellation figures, star maps appear remarkably white and empty. Flamsteed's maps were especially so: he used large Imperial paper that was about twice the size of the folio sheets used in other star atlases, including the French derivatives of his work, and he reduced the size of the cartographic signs for star magnitudes "so that I should enjoy more space" in which to work (Flamsteed 1982, 160). But there were exceptions. First, star maps were occasionally clarified in France by overprinting the constellation figures in red (see fig. 156 below). Second, two works appeared in 1799 that had been printed so as to appear white on black: a pair of celestial hemispheres by R. Brook in London and the maps in Christian Friedrich Goldbach's atlas published in Weimar (Warner 1979, 43, 96–97); Goldbach's *Neuester Himmels-Atlas*, based on Bode's edition of Flamsteed's atlas, featured two plates for each portion of the night sky, one giving a direct impression of the sky, showing just stars, the other with constellations and lines of celestial coordinate systems added (fig. 155). Despite all the variability in map elements, we can nonetheless identify further patterns in, and the development through time of, particular elements of star maps over the course of the eighteenth century.

Enlightenment star maps fall into two categories: general and detailed. General star maps, almost always circular in form and often called "planispheres" in the Enlightenment, depicted large portions of the heavens to show the general arrangement of constellations. More particularly, hemispheres depicted precisely half of the heavens (as fig. 154 above) and could be issued in pairs; planispheres per se depicted the northern celestial hemisphere plus much of the southern sky in order to show the constellations and stars revealed by the tilt of the earth's axis and recorded by Ptolemy. Planispheres were properly drawn on an azimuthal stereographic (conformal) projection (Friedman Herlihy 2007, 105n26). Hemispheres, however, could also be drawn on an azimuthal equidistant projection; there is no clear chronological pattern in the respective use of the two projections, and both were used throughout the long Enlightenment. On occasion, the band of the zodiac was mapped with a simple rectangular projection: by John Seller and Augustin Royer, both in 1679; John Senex in 1718; Pierre-Charles Le Monnier in 1755 (fig. 156); and Samuel Dunn in 1772 (Warner 1979, 233–37, 213–16, 239–44, 159–62, 68–70). All of these works appeared in association with attempts to elucidate the determination of longitude at sea by lunar distances; indeed, Tobias Mayer in 1756 completed a new catalog of zodiacal stars as part of his work on lunar tables for the longitude prize and finally published in 1775 in his *Opera inedita*.

Detailed celestial maps delineated individual constellations or groups of constellations in a manner analogous to maps of countries or regions in terrestrial atlases. Bayer had mapped each constellation on a trapezoidal projection of the same sort used for regional maps; Hevelius and Bevis would follow suit. For his *Globi coelestis*, published posthumously in 1674, Ignace-Gaston Pardies, SJ, used the gnomonic projection to remap the night sky in six large sections (fig. 157). Two polar-aspect and four equatorial-aspect maps each extended 45° from their center (Warner 1979, 196–98). In the text panels explaining the maps, Pardies asserted that this arrangement adequately reproduced the proportions of the figures of each constellation as seen by an earthbound viewer. Yet it seems as though the real reason that Pardies used the gnomonic projection was to test whether the paths of comets did indeed form great circles, as Jean-Dominique Cassini (I) had maintained (Pardies 1674, maps 2 and 4). For his sectional maps, Flamsteed argued against the adoption of projections used for terrestrial maps and instead modified Nicolas Sanson's sinusoidal projection—with longitudes spaced along each straight parallel "proportionate to the sines of their distances to the [nearest] Pole" on either side of the central hour circle, forming sine curves—in order to maintain the shape of each constellation without significantly distorting its size (see fig. 152); this "Sanson-Flamsteed" projection would of course be used in the

(*facing page*)
FIG. 155. REPRESENTING THE NIGHT SKY DIRECTLY: WHITE-ON-BLACK STAR MAPS. Christian Friedrich Goldbach, "Steinbock [Capricorn] Wassermann [Aquarius]," in his *Neuester Himmels-Atlas* (Weimar, 1799), map 21, without (above) and with (below) the constellation figures and graticule. The two images have often been thought to be from the same plate, with impressions being pulled before and after the addition of constellations; but the plate pairs are often of different sizes, so two sets of plates were used. Mezzotint was used to capture the subtle light patterns of nebulae.
Size of the originals: both 19 × 23 cm. Image courtesy of the Special Collections Library, University of Michigan, Ann Arbor.


21
Steinbock Wassermann.


Steinbock Wassermann
21
XXIIII
XXIII
XXII
XXI
XX
Füllen
Delphin
Pegasus
Fische
Antinous
Wassermann
Wallfisch
Scheat
Steinbock
Bildhauer Werkst.
Südlicher Fisch
Fomalhaut
Microscop
Grösze der Sterne
Nebelst.

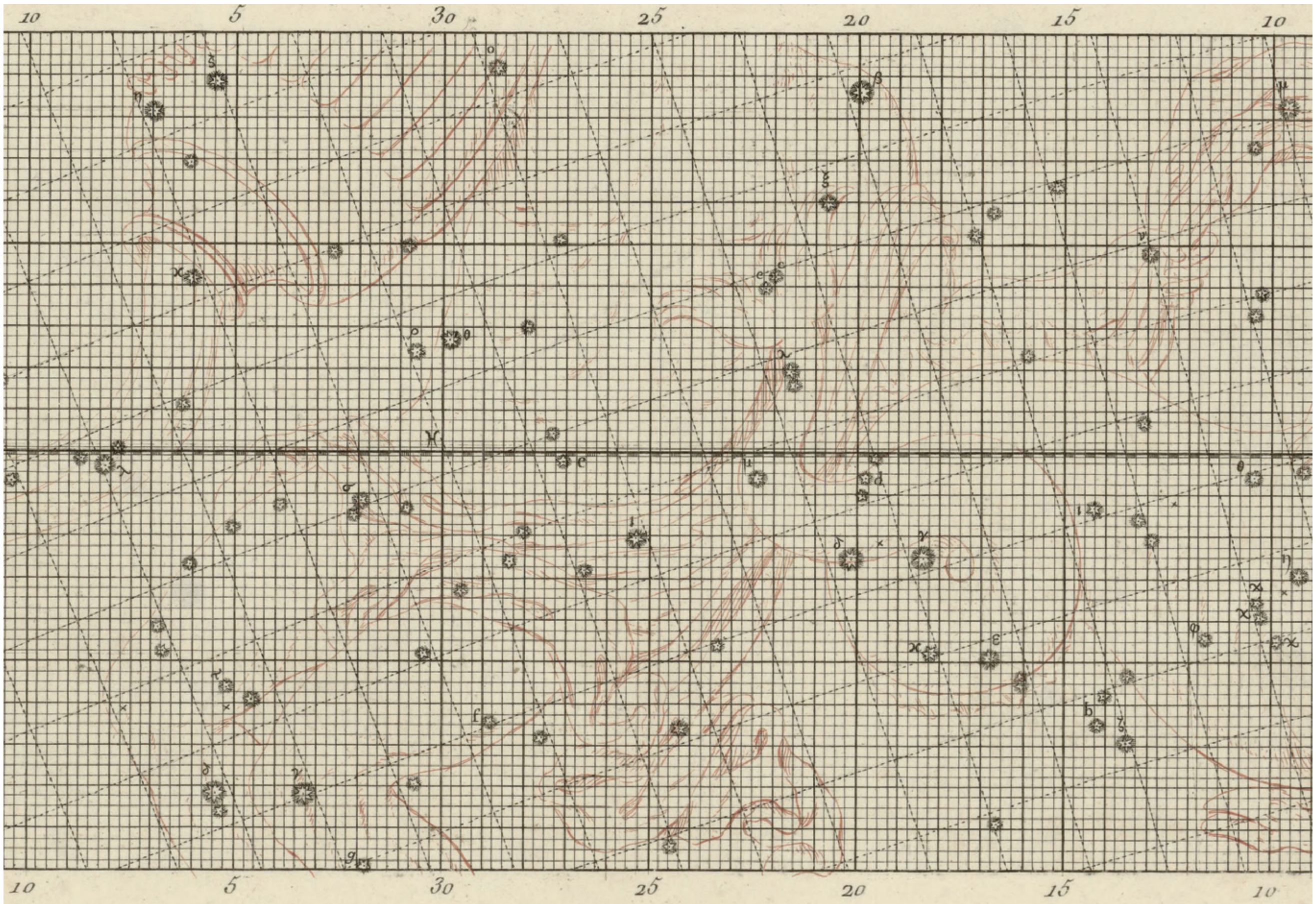


FIG. 156. DETAIL OF AQUARIUS ON A ZODIACAL MAP. This map located the primary stars and their magnitudes within each regular sign of the zodiac (each 0° to 30° celestial longitude) and within 10° latitude north and south of the ecliptic (the graduated horizontal line). The dashed, diagonal grid indicates equatorial coordinates. The constellation of Aquarius actually rests on the boundary between the signs of Aquarius (left of the 30° line) and Capricorn (to the right). Some impressions lack the constellation figures overprinted in red. Guillaume Dheulland prepared this map, *Nouveau zodiaque, qui contient les positions des etoiles fixes, que la lune et les planetes doivent rencontrer en parcourant leurs orbites* (Paris, 1755), for Pierre-Charles Le Monnier.
Size of the entire original: 53.5 × 86.0 cm; size of detail: ca. 15.5 × 22.0 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 2987 [44 B]).

several derivatives of Flamsteed's atlas (as fig. 155). For the polar regions, however, Flamsteed continued to use the azimuthal stereographic (Flamsteed 1982, 159–60).

Projecting the celestial sphere onto plane paper was complicated by astronomers' use of two stellar coordinate systems; star maps were constructed on one set of coordinates with the other usually being superimposed, often with thinner or dashed lines. Ecliptic (or celestial) coordinates of stellar latitude and longitude were determined with respect to the plane of the ecliptic, i.e., the path of the sun's apparent motion against the celestial sphere; the equivalent equatorial coordinates, determined with respect to the celestial equator, were of declination and right ascension. The zero for both longitude and right ascension was the point where the sun, on the ecliptic, crosses the equator at the spring equinox (see fig. 157) although counting varied: celestial longitude was often expressed by angular degrees within each zodiacal sign (which did not precisely match the actual constellation; see figs. 151 and 156), right ascensions by time (hours and minutes) or by degrees around the full circle. The continual movement (precession) of the spring equinox against the backdrop of the stars, caused by the wobble of the earth's axis, requires astronomers to adjust longitudes by a constant (ca. $^{1}/_{72}$°) for each year distant from the epoch of their coordinate data; precession is irrelevant for stellar latitudes. Precession affects both declinations and right ascensions by annual amounts that vary according to each star's location. Tables permitted easy translation of one coordinate system to the other.

Early star catalogs generally listed only ecliptic coordinates, reflecting the manner of taking and reducing observations of the stars. Astronomers determined stellar latitudes and longitudes by a method of distances: a moveable sextant was used to measure the angular separation of each star from its neighbors, conceptually turning the celestial sphere into a mesh of triangles from which stars' coordinates could be calculated (Volkoff, Franzgrote, and Larsen 1971, 23–30). These calculations were simplified by reference to the ecliptic; in particular, no correction needed to be applied to celestial latitudes. Moreover, most planetary motions occurred within, or close to, the plane of the ecliptic, so it made sense for astronomers to work in such coordinates. Early star maps were constructed accordingly. The maps in Bayer's *Uranometria* were all constructed with reference to the ecliptic, with lines of declination and right ascension superimposed. The same was true for Halley in the 1670s, Hevelius in 1690, and for the few eighteenth-century zodiacal maps (see figs. 153, 154, and 156).

Some early astronomers did map the heavens according to equatorial coordinates. Perhaps the first was Isaac Habrecht II, who made a pair of celestial hemispheres in 1628 that would be reprinted several times between 1650 and 1666 (Warner 1979, 104–5), and in 1674 Pardies projected his gnomonic maps with equatorial coordinates and then superimposed lines of stel-

FIG. 157. ONE-SIXTH OF THE NIGHT SKY, CENTERED ON THE POINT OF THE SPRING EQUINOX. Ignace-Gaston Pardies, *Globi coelestis* (1674), pl. 2; the constellation of Aquarius is at center right. Pardies used the gnomonic projection to map each portion of the celestial sphere; each map extended for 45° from its center, here the vernal intersection of the equator (horizontal graduated line) and the ecliptic (diagonal graduated line), which also served as the origin for both ecliptic and equatorial stellar coordinates. Pardies included comet paths; for example, the 1585 comet observed by Tycho Brahe can be seen here, passing at left through Aries toward the ecliptic. Separately printed explanatory text, in both Latin and French, was pasted onto the sides of each map. Derivatives of these maps were published throughout the eighteenth century; the 1693 edition of Pardies's work included Halley's constellations for the southern hemisphere (see fig. 154).
Size of the original: ca 49.5 × 71.5 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City.

lar latitude and longitude. The subsequent wholesale shift in structuring star maps by equatorial coordinates stemmed from the adoption of new methods of stellar observation using circles fixed vertically in the plane of the observatory's meridian and the new pendulum clocks invented by Christiaan Huygens in 1656. Such instruments made it easy to measure stellar positions by subtracting or adding a series of corrections to the observed altitude of a star, for declination, and of the time at which the star passed through the meridian, for right ascension. Flamsteed pioneered this technique (explained by Baily 1835, 267, 371–72) once he had acquired the right instruments: one of the new pendulum clocks and, in 1689, a large 140° circle with a telescope to which he added a micrometer for reading minutes of arc. (These observational techniques and instruments would be steadily refined throughout the eighteenth century.) Flamsteed inevitably framed the maps in his *Atlas coelestis* by equatorial coordinates and added lines of stellar latitude and longitude. By the 1740s, new star maps used equatorial coordinates "almost exclusively" (Ashworth 1981, 63).

A further complicating factor in projecting star maps was the perspective adopted in depicting the stars, whether from the earth (geocentric, or sky view) or from outside the celestial sphere (external, or globe view). Note that the adoption of a "geocentric" perspective does not mean that the astronomers adhered to a Ptolemaic, geocentric cosmology (Friedman Herlihy 2007, 102n16). The two perspectives were mirror images. For example, in figure 152, constructed by Flamsteed from a geocentric perspective, the head of Pisces is to the left of Aquarius, but in figure 153, constructed by Hevelius from an external perspective, the head of Pisces is to the right. In adopting the external perspective, early makers of star maps perhaps sought to permit their maps to be compared directly to celestial globes, for which the perspective is innate, rather than to the night sky. Objections had already been raised in the seventeenth century—Flamsteed (1982, 158–59) cited Wilhelm Schickard's *Astroscopium* (1623) in arguing that the external perspective can only confuse casual viewers of the night sky—and the external perspective seems after 1700 to have been limited to commercial works intended for the public.

The issue of perspective also affected the drawing of the constellation figures. In principle, constellations should be drawn as if facing down on the earthbound observer (as in fig. 152); an external observer would see their backs (as in fig. 153). Bayer, however, had confused the principle by drawing most of his constellations from the rear, but with a geocentric perspective. This practice seemed to make a mockery of the Ptolemaic system for naming and locating stars: the star that Tycho's catalog placed in the left shoulder of Aquarius now appeared in the right, and vice versa, so that the astronomer was guaranteed to be led to the wrong star. Bayer had corrected for this problem by identifying, for the first time, each star within a constellation according to its magnitude as listed by Ptolemy: α for the brightest, β for the next, and so on. These labels superseded the Ptolemaic labels and ensured the utility of Bayer's maps.

Flamsteed (1982, 157–58) would complain about Bayer's seeming contravention of basic principles and argued that Bayer had been confused by incorrect translations of Ptolemy's names for each star. Flamsteed nonetheless adopted Bayer's new system of labeling stars (Hevelius did not). Subsequently, astronomers followed Flamsteed's perspective—geocentric with constellations shown from the front—as they further adapted his catalog and atlas. Also, with the proliferation of the number of known, located stars, they used the sequence of stars in his catalog to define "Flamsteed numbers" to label each star within a constellation; while this innovation was credited to Lalande in his *Éphémérides* (1783), it had certainly been implemented previously by Bode in the anonymous *Sammlung astronomischer Tafeln* of 1776 and perhaps even earlier by Bevis in his abortive atlas, ca. 1750 (Kilburn, Pasachoff, and Gingerich 2003, 137–38).

A final variable element within Enlightenment star maps was the depiction of celestial features other than the fixed stars. Underlying stellar astronomy throughout the early modern era, distinct from the establishment of a fixed reference system for analysis of planetary movements, was the growing realization that the stars were not necessarily fixed and unchanging (Hoskin 1982). Many novas—new stars, even if short-lived—had been observed since Tycho had recorded that of 1572. Other stars seemed to vary in magnitude. Still others, when examined in telescopes, stubbornly remained vague and nebulous; after 1758, Charles Messier cataloged 110 nebulae so that he could eliminate them from consideration during his search for comets; he published his first catalog in 1784. Flamsteed, working strictly to solve the problem of longitude at sea, mapped only the fixed stars and ignored both nebulae and novae. But subsequent astronomers progressively included them in their star maps.

Star catalogs and atlases were therefore also historical works, as astronomers sought to bring older catalogs into alignment with the new in order to discern changes. Astronomers had to adhere to long-standing traditions in the naming of constellations and stars to maintain the retrospective view (Flamsteed 1982, 29–109, 156–57). The search for comparative data extended to China: Min Mingwo (the Chinese name of Philippe-Marie Grimaldi, SJ) published in Beijing in 1711 a nine-sheet atlas derived from Pardies's maps, which indicated traditional Chinese constellations; this work served as the basis for the hemispheres of Western and Chinese constellations that were published by Chrétien-Louis-Joseph de Guignes in 1785 specifically to enable Western astronomers to interpret Chinese astronomical data (Warner 1979, 102–3).

In addition to mapping the location of the moon, planets, and comets against the stars, early modern astronomers also studied those objects themselves. A burst of activity in the first half of the seventeenth century, after the introduction of the telescope, led to comprehensive mapping of the moon. This effort was in part driven by the idea of using the passage of the earth's shadow across the moon during a lunar eclipse to determine terrestrial longitudes: to time the eclipse, observers would need to be able to refer to precise locations on the moon's surface. By 1647, Hevelius could publish his first major work, the *Selenographia, sive lvnæ descriptio*, with comprehensive maps of the moon as seen in different phases and taking into account the moon's slight "nodding" motion (libration). While Hevelius's map remained the dominant image of the moon for the next 150 years, his nomenclature was quickly displaced by that provided in the popular *Almagestvm novvm* of 1651 by Giovanni Battista Riccioli, SJ (Whitaker 1999, 47–68; Van Gent and Van Helden 2007). Interest in moon mapping continued through the end of the seventeenth century. Ewen A. Whitaker (1999, 71–85) identified the new maps published by several astronomers, many of which were subsequently degraded by being repeatedly copied in popular works after 1700: Geminiano Montanari in 1662; the friar Chérubin d'Orléans (i.e., Michel Lasséré) in 1671; Cassini I in 1679 (large, 54 cm diameter, and rare) and 1692 (small, in anticipation of a total eclipse); Georg Christoph Eimmart in 1694; and Philippe de La Hire in 1702.

Interest in mapping the moon was far more sporadic after 1700, perhaps because observations of the eclipses of Jupiter's satellites had become the preferred technique for determining longitude on land. Prompted by a lunar eclipse in August 1748, Tobias Mayer thought to resurrect the idea of using lunar eclipses for precise longitude determination, but he found both Hevelius's and Riccioli's maps to be inadequate. Seeking to measure libration precisely, he carefully determined the locations of key features by their angular separation from the moon's northern and western limbs, effectively imposing a graticule of selenographic latitude and longitude (Forbes 1980, 43–53). From these observations, he made a lunar map, making explicit the orthographic projection that earlier maps had deployed. The map would not, however, be published until 1775 (fig. 158); by contrast, he did not complete preparation of his lunar globe. (This work complemented Mayer's observations of lunar motion for determining longitude at sea.) Johann Heinrich Lambert also measured some precise locations on the moon's surface, but the map accompanying their publication in 1776 was small and imprecise (Whitaker 1999, 82–85).

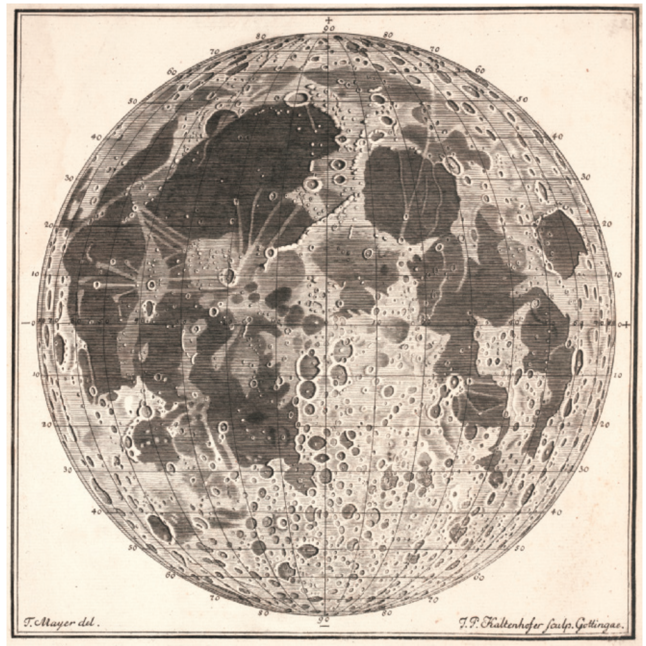


FIG. 158. TOBIAS MAYER'S LUNAR MAP. Originally prepared by Mayer in about 1750, it was eventually published in his *Opera inedita* (1775), vol. 1, map plate; the editor, Georg Christoph Lichtenberg, added the digits for selenographic latitude and longitude.
Size of the original: 21 × 21 cm. Image courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City.

Mapping of the sun and planets followed a similar pattern as moon mapping: an initial enthusiasm in the seventeenth century fueled by the invention of the telescope, undertaken by many of the same observers, followed by sporadic interest for most of the eighteenth century. Early observations were limited by the quality of telescopes, and each observer recorded different aspects of the sun and each planet (fig. 159). Once Giacomo Filippo Maraldi had in 1719 duplicated Cassini I's 1666 determination of the rotational period of Mars, interest in Mars waned (Sheehan 1996, 16–41). Venus offered very few features, although this did not stop Francesco Bianchini from preparing manuscript globes of Venus in 1727. Athanasius Kircher's map of the surface of the sun, in the second book of his *Mundus subterraneus* (1664–65), would be echoed by Cassini I in 1671 and then throughout the eighteenth century by astronomers seeking to understand the phenomenon of sun spots.

In 1781, William Herschel observed what he thought

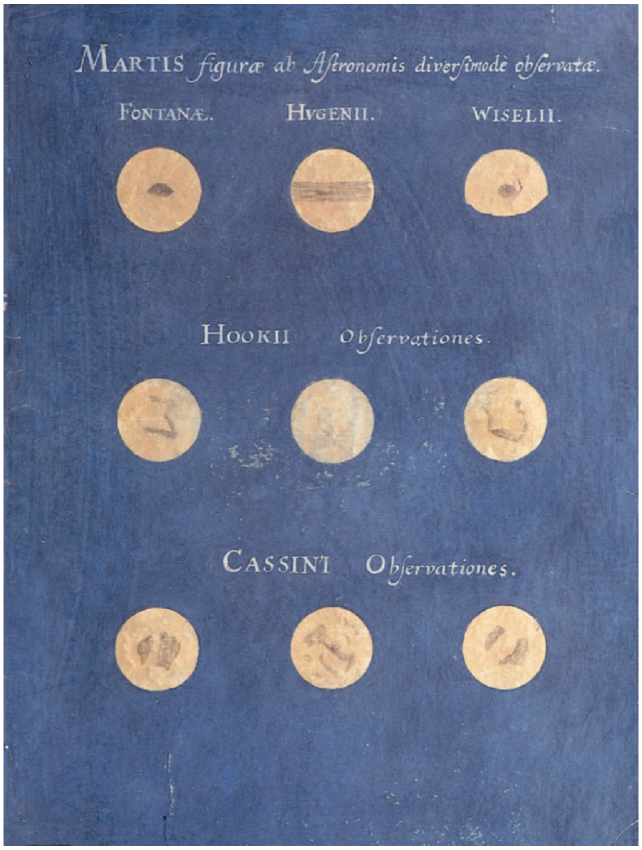


FIG. 159. EARLY PLANETARY MAPS, CA. 1700. Keen amateur astronomer Maria Clara Eimmart, daughter of the Nuremberg cartographer and engraver Georg Christoph Eimmart, painted summaries of the aspects of the planets, including Mars (left) and Jupiter (right), as they had been observed by various seventeenth-century astronomers. These images, pastel on blue cardboard, are from a collection of twelve diagrams. She also made some 350 drawings of the moon's phases on blue paper between 1693 and 1698.
Width of the originals: ca. 52 cm. Museo della Specola, Department of Physics and Astronomy and University Museum System, Alma Mater Studiorum–University of Bologna (Inv. MdS-124h, Inv. MdS-124i).

was a comet but which turned out to be a new planet, Uranus. This led to a new enthusiasm for detailed observations of the planets. Johann Hieronymus Schröter created an observatory specifically for planetary observation, and in about 1787 he began a systematic program of observation. He was the first to sketch aspects of Mercury, and he remapped the moon, building on Mayer's work and publishing seventy-five detailed maps in his *Selenographische Fragmente* (2 vols., 1791–1801), all indexed to a reprint of Mayer's map (Whitaker 1999, 98–109).

What did hold the attention of astronomers throughout the eighteenth century were comets. In popular culture, comets were seen as harbingers of doom and disaster. Stanisław Lubieniecki undertook an exhaustive review of the past appearances of comets in his two-volume *Theatrum cometicum* (1666–68), which included a number of maps of comets similar to figure 150 and also naturalistic sketches of the comets and their tails, and he concluded that comets had no correlation to disasters on earth. This had little effect on popular prognosticators, however, who were especially motivated by the extra-bright comet of 1680 to raise alarms (Hughes 1990, 328–30). But for astronomers, comets posed a challenge, not least to determine their orbits and so their nature as part of the ongoing effort to understand the structure of the solar system. The first task for astronomers was to convert the path of the comet as it was tracked across the celestial sphere into the parameters of its actual orbit, taking into account the earth's own orbital motion between observations (fig. 160, left side). In particular, Hevelius included complex diagrams of comet orbits together with maps of their paths against the stars in both his *Prodromus cometicus* (1665) and *Cometographia* (1668), while Pardies graphically tested Cassini I's claim that comets moved as great circles.

By the 1670s, micrometer-equipped telescopes permitted astronomers to precisely measure the parallax of comets—the apparent change in their location against the stars when observed from different places at the same time—and so determine their distance from the earth, which in turn permitted more precise determination of their orbits. Flamsteed could thus determine that the comets of November and December 1680 were actually one and the same; his observations gave Isaac Newton the evidence he needed to prove that comets moved in

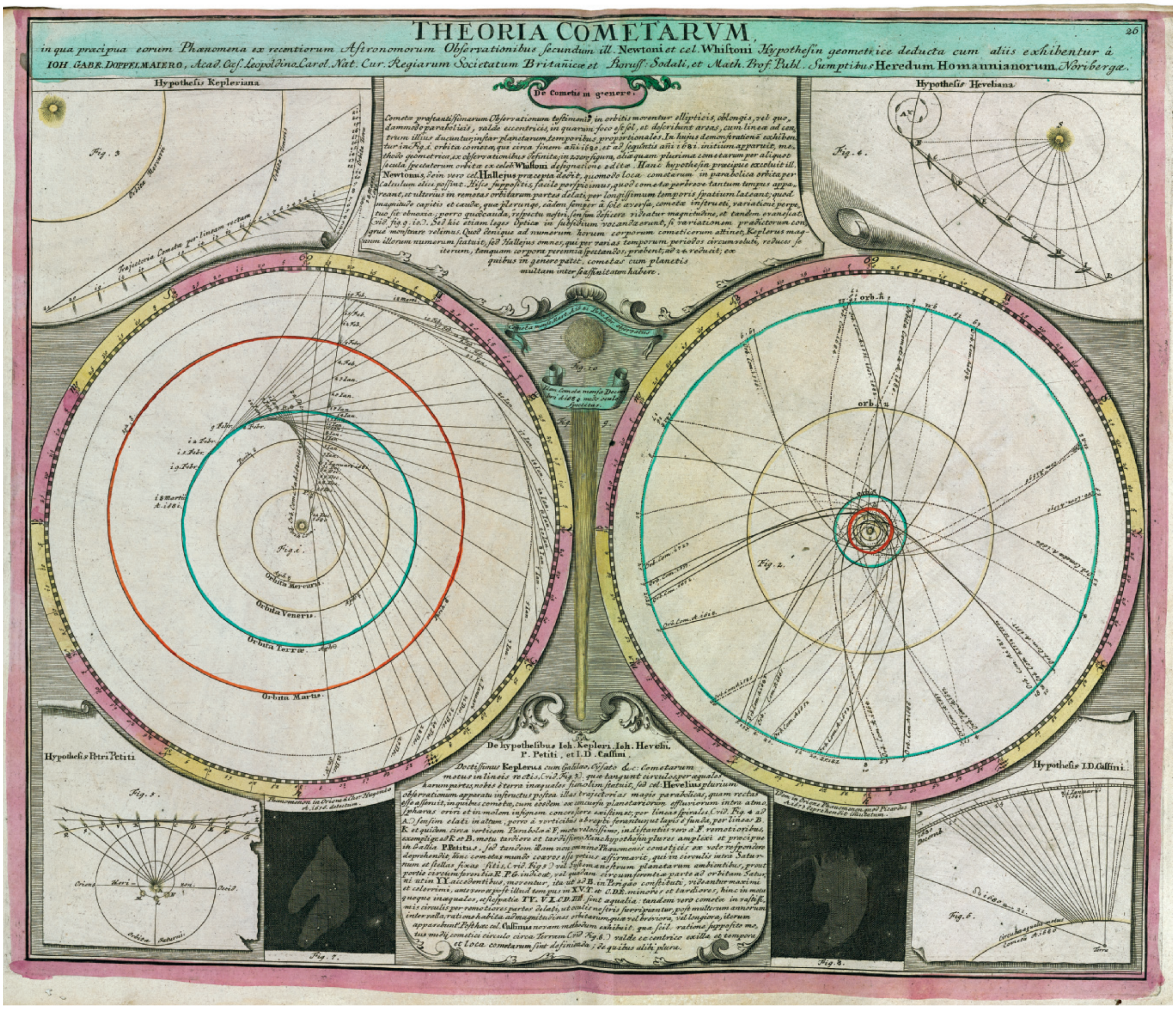


FIG. 160. THE THEORY OF COMETS. *Theoria cometarvm*, in Johann Gabriel Doppelmayr, *Atlas novvs coelestis* (Nuremberg: Homann Heirs, 1742), pl. 26. The spandrels of this multipart diagram, constructed like a double-hemisphere world map, presented models of cometary motion as proposed by Kepler, Hevelius, Pierre Petit, and Cassini I. The main figures present, in two dimensions, maps of cometary orbits according to Newtonian theory: left, how observations of the comet of 1680 from the moving earth ("Orbita Terræ," in blue) were converted into a long, parabolic orbit (uncolored) that extended out past the planets (see fig. 161); right, known comet orbits, i.e., the twenty-four calculated by Halley (1705) plus the comet of 1723. This complex diagram followed Doppelmayr's reprinting of Pardies's six sectional star maps (see fig. 157), updated with still more comet paths.

Size of the original: ca. 54 × 63 cm. Image courtesy of the Osher Map Library and Smith Center for Cartographic Education at the University of Southern Maine, Portland (SM-1742-3).

the same kinds of orbits as planets, albeit with great eccentricity (fig. 161), and thereby refute René Descartes's mechanistic model of the cosmos (Heidarzadeh 2008, 53–124). When Halley later recalculated the parameters of twenty-four comets on the basis of Newton's model, publishing the results in 1705, he famously discovered that the comets of 1531, 1607, and 1682 shared remarkably similar orbits and were likely the same comet that would return in about December 1758 (Hughes 1990, 335–64; Heidarzadeh 2008, 132–34). Halley demonstrated how precise parameters could represent each comet's orbit; thereafter, the continuing production of maps of comet paths against the stars and in cosmological diagrams (fig. 160, right side) were intended more for popular readers of astronomy, cosmology, and geography, especially in advance of the predicted return of Halley's comet (Waff 1990).

A large proportion of the celestial maps printed during the Enlightenment—whether star maps, moon maps, or cosmological diagrams—were intended for consumption by the growing public. As Deborah Jean Warner's 1979 catalog suggests (also Kanas 2012, 191–223), no geographical atlas worth its name was complete without at least a plate explaining globes and armillary spheres and celestial hemispheres, often presented in the same format as double-hemisphere world maps (fig. 162). Hemispheres and cosmological diagrams also appeared in the spandrels of world maps (see fig. 951); such marginal imagery sustained the decorative qualities of world maps, even as the high baroque decoration of seventeenth-century dedicated star atlases steadily became plain through the eighteenth century (Burnham 2005, 12). Copied from whatever sources were at hand, these images form consistent elements: diagrams of the pre-Newtonian cosmological systems by Ptolemy, Copernicus, and Tycho; images of the moon, sun, and planets, mostly from pre-1650 sources; comet diagrams; and explanations of celestial geometries (lunar and solar eclipses, phases of the moon, seasons, etc.). Overall, such imagery was formulaic, rarely innovative, and prettified for the public by the use of color.

Some celestial imagery intended for popular audiences was brought together in dedicated atlases. In addition to Seller's *Atlas cœlestis* (1680) and Samuel Dunn's *A New Atlas of the Mundane System* (1774) (Warner 1979, 236–37, 70; Kanas 2012, 204–5, 212–14), two atlases were of special note. Andreas Cellarius's ornate *Harmonia macrocosmica* (1660) provided a historical introduction to cosmology; it appeared as the cosmological supplement to Johannes Janssonius's multivolume *Atlas novus*, with extensive Latin text accompanying the twenty-nine plates (Van Gent 2006). Johann Gabriel

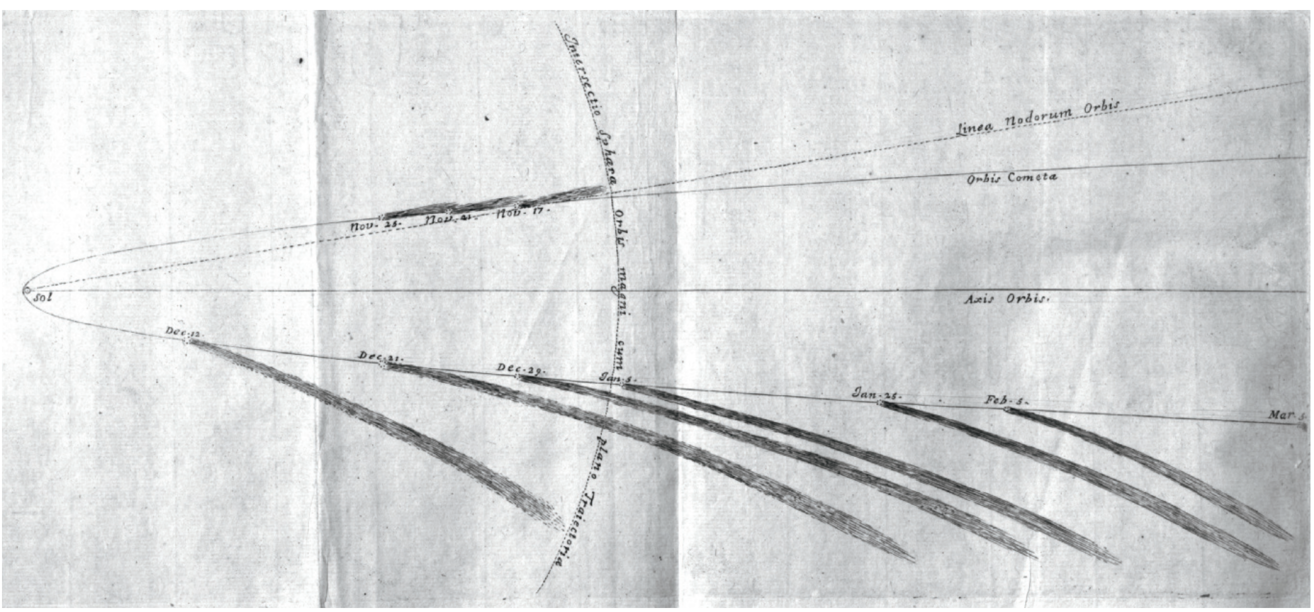


FIG. 161. ISAAC NEWTON'S MAP OF THE COMET OF 1680. From book 3 ("system of the world") of his *Philosophiæ naturalis principia mathematica* (London, 1687), between 496 and 497. This diagram shows the location of the comet and the size and orientation of its tail as seen in November 1680 as it approached the sun ("sol" at far left) and then in December 1680 through March 1681 as it retreated. The transverse arc shows not the earth's orbit but its projection onto the plane of the comet's trajectory; that is, this is a two-dimensional rendition of a three-dimensional relationship.
Size of the original: 13.0 × 29.4 cm. Image courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin–Madison.

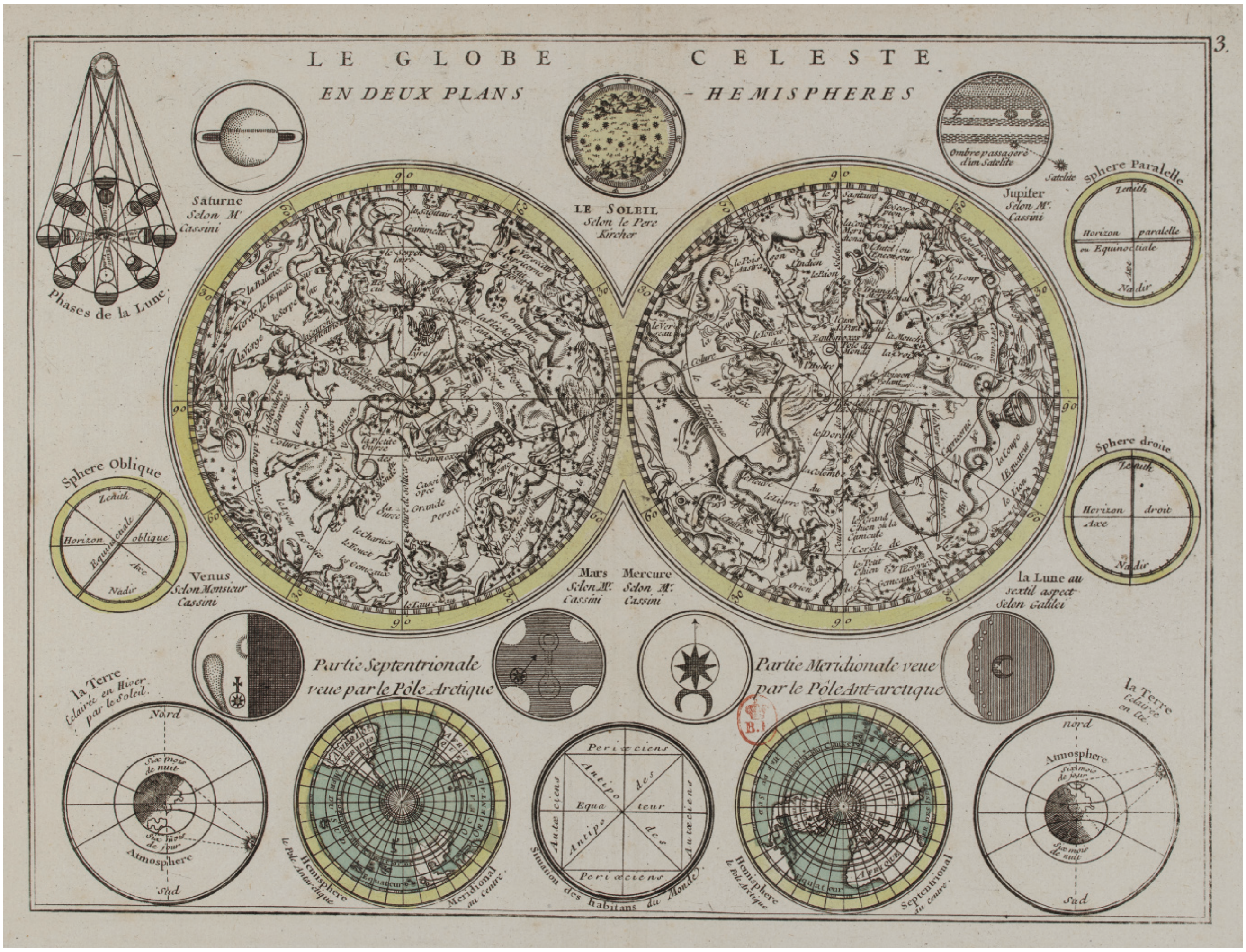


FIG. 162. THE HEAVENS IN TWO HEMISPHERES. *Le globe celeste en deux plans hemispheres* from Georges-Louis Le Rouge, *Atlas nouveau portatif,* 2 vols. (Paris, 1756–59), vol. 1, pl. 3. Le Rouge copied these small planispheres from those by La Hire of 1719, who had constructed them from images in Bayer's *Uranometria* (1603). The wide margins are filled with small cosmological illustrations, including views of the planets and explanations of summer, winter, and the moon's phases. Size of the original: 21.4 × 28.3 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge FF 823 [t. 1]).

Doppelmayr made a number of cosmological maps for Johann Baptist Homann, with the first two appearing in Homann's *Neuer Atlas* (1707), specifically an ornate diagram of the heliocentric cosmos and a copy of Hevelius's moon map. Doppelmayr's plates grew less ornate, and more text heavy (see fig. 160), and were combined in 1742 by the Homann Heirs into the *Atlas novvs coelestis* (Warner 1979, 64–67; Kanas 2012, 191–94, 209–11, 502–3).

These atlases and other celestial images were, at heart, didactic. Cheaper plates, or sets of plates, were prepared for atlases and separate sale, such as those published in Amsterdam, each constituting a "single-sheet astronomy course" (Warner 1979, 166). Placed in conjunction with geographical maps and atlases, the general star maps and diagrams reinforced the interconnection of astronomy and geography and especially the manner in which astronomical observations underpinned the intellectual structure of Enlightenment geography (Edney 1994). Together with celestial globes, the popular hemispheres perpetuated the confusion of constellation figures and map perspective, but then they were not intended as graphic indexes to the heavens; their presence was symbolic rather than instrumental.

MATTHEW H. EDNEY

SEE ALSO: Astronomical Models; Constellations, Representation of; Cosmographical Map; Eclipse Map, Solar; Flamsteed, John; Globe: (1) Celestial Globe, (2) Lunar Globe; Hevelius, Johannes; Longitude and Latitude; Mayer, Tobias; Modes of Cartographic Practice; Pardies, Ignace-Gaston

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Celestial Mapping by Denmark and Norway. In the late sixteenth century, Tycho Brahe was by far the most important astronomer in the kingdom of Denmark-Norway (Friedman Herlihy 2007, 101). At his observatory on the island of Hven, he determined anew accurate star positions that were rapidly adopted for celestial globes and charts across Europe. Tycho's star catalog did not, however, initiate any Danish-Norwegian production of celestial maps and globes as it did elsewhere in Northern and Western Europe. Denmark simply imported cartographers and engravers from other countries, and the celestial maps and globes found in Danish museums and collections are, with few exceptions, made by foreign craftsmen. One explanation for this may be found in the fact that no Danish astronomer after Tycho made accurate observations of stars that could have led to a zeal for having these observations published on maps or globes. In 1706, Ole Rømer made very accurate star observations, but he never had the time to have them reduced and made public.

The Danish kings and Duke Frederik III of Holstein-Gottorp had globes made not so much for astronomical purposes but more to add to their own reputation as supporters of the arts. Thus in 1650–64, Andreas Bösch from Limburg made the large Gottorp globe under the direction of Adam Olearius, a librarian and mathematician serving the duke. The outer surface was a terrestrial globe, while inside the globe up to ten people at a time could see the stars depicted on its inner surface (fig. 163). The big stars were made of silver and the smaller ones were gilt, being placed in accordance with Tycho's catalog. The whole globe could rotate around its axis, driven by a water mill. It was placed in the duke's amusement garden. It was later given to Czar Peter I and is now in St. Petersburg (Kejlbo 1995, 83–90; Lühning 1997). A similar globe was ordered by the Danish king Christian V and constructed by Erhard Weigel from Pfalz (Palatinate). Its diameter was ten feet, and it was shown to the royal party when it arrived at the king's summer residence on 4 October 1696.

The Hauch Physiske Cabinet in Sorø, Denmark, has

FIG. 163. STARRY SKY, INTERIOR OF THE GOTTORP GLOBE, 1654–64. The globe was restored ca. 1747. Diameter of the original: 3.1 m. From the collection of the Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences (Rossiyskaya Akademiya nauk), St. Petersburg (MJI-2663-1).

several celestial globes. The collection served as a research laboratory, and as such its founder, Adam Wilhelm Hauch, purchased many scientific instruments; among these were celestial globes that are still preserved in the museum (Kejlbo 1995, cat. nos. 11–13, 41–42, 101). The Kongelige Bibliotek in Copenhagen has a celestial globe from 1758 made by the Swiss mathematician Thomas Spleiss (Kejlbo 1995, cat. no. 81). At that time a grand survey of Denmark began, and many terrestrial maps were produced, but celestial mapping in Denmark-Norway was not at the forefront.

KURT MØLLER PEDERSEN

SEE ALSO: Denmark and Norway

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Celestial Mapping by France. The period of 1650 to 1800 in France corresponds to the considerable development of both astronomy itself and the French production of maps of the heavens for many reasons: the appearance in the seventeenth and eighteenth centuries of a number of significant comets; the continuous improvement of observational instruments, which allowed an increased number of stars to be seen; the improved precision of timekeepers for measuring the course of sidereal movement; and the multiplication of long-distance voyages, which brought back observations of stars heretofore unknown to Europeans or of stars previously badly positioned on European star charts. Overall, these developments in France owed much to the creation of the Académie des sciences and the Paris Observatory, due to the influence of Jean-Baptiste Colbert, minister of state to Louis XIV. To participate in the observatory, the king brought the Italian astronomer Jean-Dominique Cassini (I) to France in 1669. Although the goal, as Philippe de La Hire pointed out, was first to employ the celestial observations as the necessary means for secure navigation and to create a sound base for geodesy (La Hire 1704, 46), the astronomers and institutions also stimulated French map production.

Two types of celestial map developed in France: small-scale heavenly planispheres and globes, both of which represent the totality of constellations; and medium-scale maps of specific celestial regions, made in order to study the route of a comet or some other celestial phenomenon. Examples of each type are described here.

Small-scale maps of the heavens (celestial planispheres) were published by the astronomers themselves; they combined precision with a particularly decorative character, as for example those of La Hire, published in 1705 by Nicolas de Fer in *L'Atlas curieux*. The planispheres of the cartographer Didier Robert de Vaugondy (*Hémisphère céleste arctique, Hémisphère céleste antarctique,* 1764) comprised a grid-like band that encompassed the regions of the zodiac, allowing the observer to find the daily position of the planets.

The atlas *Globi coelestis in tabulas planas redacti descriptio* by Ignace-Gaston Pardies (1674), included six maps presenting a portion of the celestial vault with constellations and stars and also visible comets that traversed the sky (see fig. 157). A second edition of 1690 integrated Halley's comet, observed by Cassini I in 1682. Pardies's maps, complete with new comets, were republished by Johann Gabriel Doppelmayr in 1742.

Celestial globes, like their terrestrial counterparts, also multiplied. Vincenzo Coronelli used the astronomical works of Augustin Royer, published in 1679, for his very large (4 m diameter) globes created in Paris between 1681–83 for Louis XIV. Didier Robert de Vaugondy also constructed a celestial globe of 18 inches (ca. 45 cm) in 1751 for the use of the Navy (Pedley 1992, 43–47), and Jean Lattré followed suit with a 31-centimeter globe in 1775, based on the work of Joseph-Jérôme Lefrançais de Lalande. Older than the Robert de Vaugondy and Lattré globes, a celestial globe by the abbé Jean Antoine Nollet (fig. 164) used a darker color, which made the fig-

FIG. 164. ABBÉ NOLLET, *GLOBE CELESTE CALCULÉ POUR L'ANNÉE 1730,* PARIS AVEC PRIVILEGE DU ROY, 1730. Jean Antoine Nollet, well known for his public experiments in physics, electricity, and magnetism, constructed this globe in the fashion of the time, with anthropomorphic figures representing the constellations, which he had deeply colored in order to highlight the stars, thus allowing the observer to more easily see the constellations in their natural state. Engraved sheets with illumination of blue-green and added gold to highlight stars and added silver for the great circles.
Diameter of the original: 32.5 cm (46.0 cm with the horizon table); height: 55.0 cm (in a footed tripod of turned and sculpted wood). Image courtesy of the Bibliothèque nationale de France, Paris (Ge A 1742 RÉS).

ures of the constellations less obtrusive, privileging the position of the stars to facilitate observation. Nollet's globes showed "the natural state of the heavens" and began a trend toward showing only the stars, which would continue to the end of the century (Dahl and Gauvain 2000, 162–66).

Medium-scale maps of celestial regions emphasized new stars, comets, and the moon. The *Cœlum australe stelliferum* (1763) by Nicolas-Louis de La Caille incorporated an augmented catalog of stars of the Southern Hemisphere, a result of his sojourn at the Cape of Good Hope from 1751 to 1753 (fig. 165). The new constella-

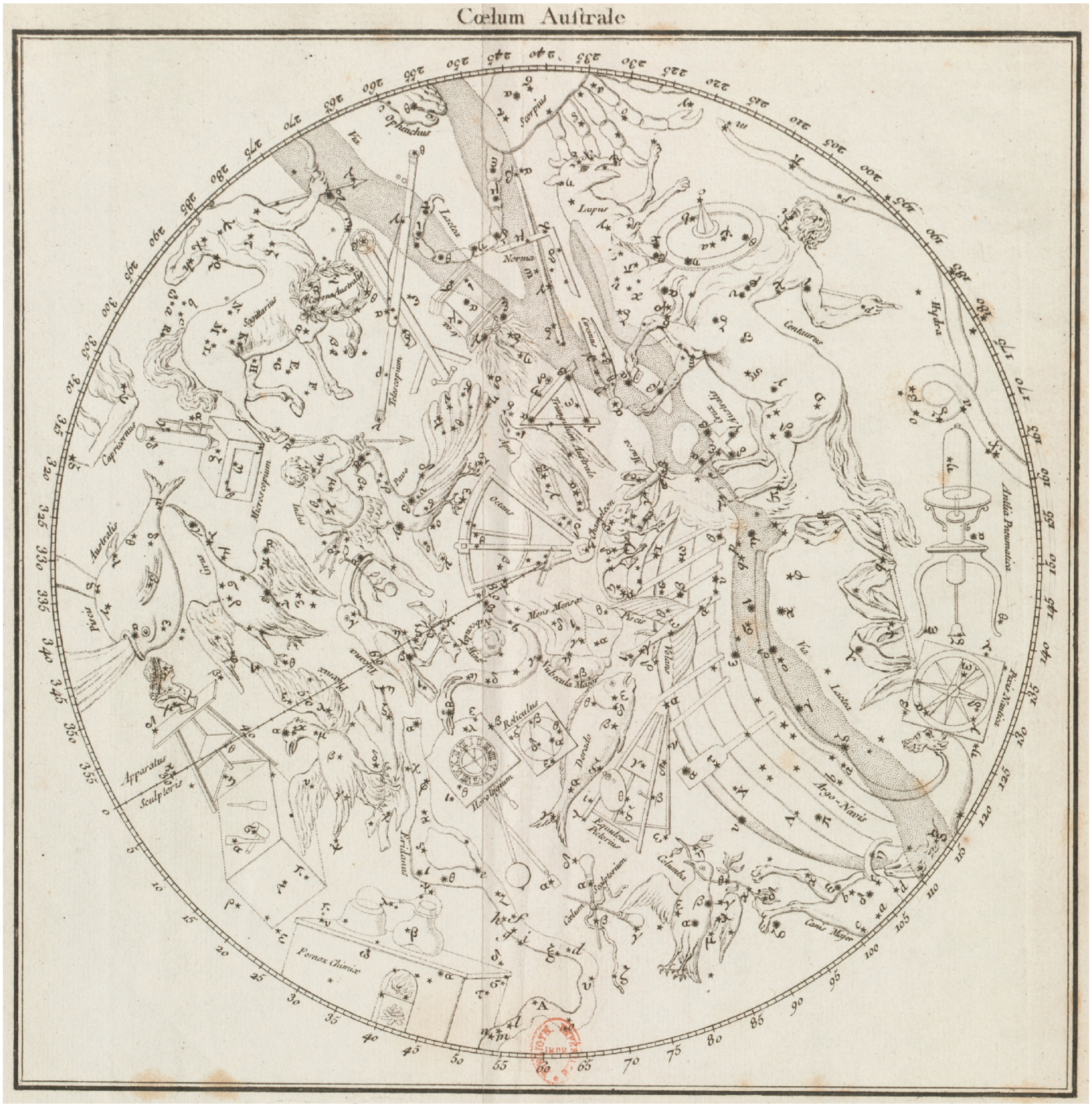

FIG. 165. NICOLAS-LOUIS DE LA CAILLE, *CŒLUM AUSTRALE*, PARIS, 1763. La Caille's *Cœlum australe stelliferum,* published in 1763, the year after his death at age forty-nine, includes only a small portion of his southern observations, made en route to South Africa. During the voyage, to test the lunar distance method of determining longitude, he noted the positions of about 10,000 stars using a very large sextant.
Size of the original: ca. 20.5 × 20.5 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

tions bore the names of scientific instruments (the Pneumatic Machine, the Compass, the Clock, etc.), replacing the Greco-Roman names from ancient mythology (see fig. 183). Charles Messier observed comets with a mural half-circle in the observatory in the Hôtel de Cluny to produce comet maps from 1765 to 1790. The moon occupied Cassini I, who presented his *Carte de la lune* to the Académie des science in 1679 and published it in 1680. His map remained the basic reference lunar map until the nineteenth century and the early use of photography.

The style of the representation of the constellations changed over the course of the century. A sober approach with stars symbolized by increasing magnitude and constellations drawn with simple lines distinguished a graphic style that facilitated scientific work. It gradually replaced the sumptuous anthropomorphic representations so richly displayed in the work of Coronelli and his followers.

HÉLÈNE RICHARD

SEE ALSO: Cassini Family: Cassini (I), Jean-Dominique; France; La Caille, Nicolas-Louis de; Paris Observatory (France)

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Celestial Mapping by Great Britain. During the period from 1650 to 1800, celestial cartography in Great Britain reflected the scientific curiosity of the Enlightenment as well as the need for accurate printed star maps to assist with the problems of determining longitude at sea and navigating in the Southern Hemisphere. To create an accurate star catalog that would meet the needs of the maritime and scientific communities, Charles II created the Greenwich Observatory with John Flamsteed as the first astronomer royal in 1675. But other English scientists contributed to celestial cartography as well.

In 1676 Edmond Halley undertook a voyage to the island of St. Helena, where he made the first telescopic observations of 341 southern stars. The resulting catalog, *Catalogus stellarum australium* (1674), was used for many subsequent star atlases. He also produced maps of the celestial hemispheres that were unconventionally centered on the north and south ecliptic poles. The southern map (see fig. 154) introduced the now-obsolete constellation Robur Carolinium, which depicted the oak tree in which Charles II had hidden from Oliver Cromwell's soldiers in 1651.

Flamsteed directly influenced John Hill, a physician, naturalist, apothecary, and scientific writer who worked in London. Hill's *Urania: Or, a Compleat View of the Heavens* (1754) contained thirteen celestial plates, including a hemisphere of the southern skies. He derived his constellations mainly from Flamsteed, but a number were of his own invention, being taken from the animal world, such as a scaly lizard, a black snail, a leech, and different kinds of shellfish.

One of the more interesting and tragic stories in celestial cartography during this period involved John Bevis. Although trained as a physician, Bevis pursued his interest in astronomy until it became a full-time occupation. In 1731, he was the first European to record the Crab Nebula, and on 28 May 1737 he made the first recorded observation of the occultation of one planet by another (Venus eclipsing Mercury). From 1746 to 1750, Bevis worked on a new star atlas that he hoped would surpass that of Flamsteed. Originally called "Uranographia Britannica," it was patterned after Johannes Bayer's famous atlas of 1603, but with improvements: there were additional stars from the catalogs of Johannes Hevelius, Flamsteed, Halley, and Bevis himself; there were more constellations; and for the first time in any star atlas, a number of deep sky objects were depicted (including the Crab Nebula and the Andromeda Galaxy). Some of Bevis's accurate and beautiful star charts began to be printed in 1749. However, the next year John Neale, his main financial backer, went bankrupt, and the atlas copperplates were sold off as scrap. Fortunately, bound sets of Bevis's maps began appearing on the market in 1786 under the title *Atlas celeste*, probably from charts sold at an estate auction in 1785 (fig. 166).

Other English cartographers and mapsellers were notable for producing and selling celestial globes and maps derived from these scientists' works, even though a few had scientific aspirations as well. John Seller established a shop near the Tower of London that sold nautical charts, terrestrial and celestial maps and globes, and instruments. In 1671, he was appointed hydrographer

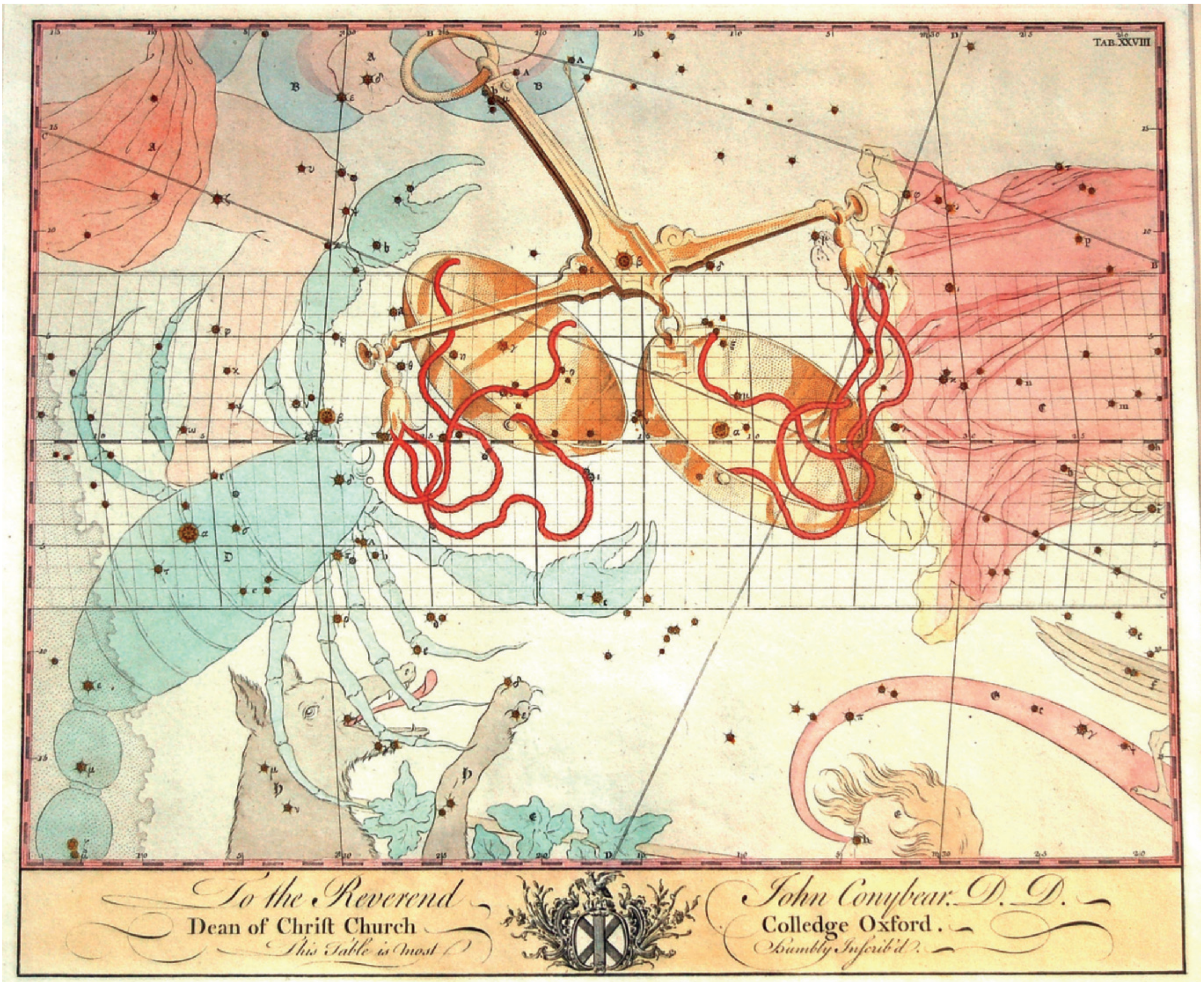

FIG. 166. THE CONSTELLATION LIBRA FROM JOHN BEVIS'S *ATLAS CELESTE*, [1786], PL. XXVIII. Note the central grid that represents the zodiac and the dedication at the bottom to the Dean of Christ Church, Oxford, one of the financial contributors to the atlas. Size of the original: 26.8 cm × 36.3 cm. Image courtesy of the Nick and Carolynn Kanas Collection.

to Charles II. This gave him a monopoly on publishing nautical atlases, such as his famous *Atlas Maritimus*, *or the Sea-Atlas,* first appearing in 1675. Several celestial charts were bound into various editions of this composite atlas, including a copy of Halley's southern celestial hemisphere and Halley's 1679 chart designated as the first published map of the zodiac (Warner 1979, 233, 235). In 1680, Seller produced a small atlas titled *Atlas cœlestis: Containing the Systems and Theoryes of the Planet*, which was one of the first "pocket" astronomical atlases. It contained several maps of the heavens, including thirty-one double-page constellation images and a plate depicting the two celestial hemispheres (fig. 167).

Joseph Moxon, like Seller, was hydrographer to Charles II and a fellow of the Royal Society, as well as a distinguished globe- and instrumentmaker. He published several celestial hemispheres including those in *A Tutor to Astronomy and Geography* (3d ed., 1674). Francis Lamb was another London engraver and cartographer who produced celestial hemispheres, some of which included insets of various cosmological systems and maps of the earth and moon. The mapseller, globemaker, and instrumentmaker Philip Lea copied two of Lamb's 1673 hemispheres but added data from Halley's work in his southern map.

Another important celestial cartographer and mapseller was John Senex. Also a fellow of the Royal Society, he had a successful career as an engraver and as a map

FIG. 167. TWO CELESTIAL HEMISPHERES FROM JOHN SELLER'S *ATLAS CŒLESTIS*, 1680. Note the traditional constellation images, the signs of the zodiac circling the images, and the outlines of the planets with their symbols at the bottom. Diameter of each hemisphere: ca. 7 cm. Image courtesy of Jonathan Potter Limited, London.

and book publisher in London. Being interested in astronomy, he collaborated with leading scientists, including Halley. There was no reliable and extensive star atlas in England during the first quarter of the eighteenth century, since Seller's charts were not conducive to high-quality astronomical work and Flamsteed had not yet published his great atlas. Senex produced a number of celestial maps that helped fill this void, including a chart of the zodiac constellations in 1718, two celestial hemispheres ca. 1721, and a northern celestial planisphere in 1746 that was used by Charles Messier to map the path of Halley's comet in 1758–59.

Finally, mention should be made of Samuel Dunn, who worked as a school principal in Devon before moving to London (Brown 1932, 52). From the 1750s to the early 1790s, he authored several books and maps. One of his most popular works was *A New Atlas of the Mundane System*, printed in 1774. This book had six celestial charts: four cosmographical diagrams and a northern and a southern celestial hemisphere indicating the constellations but without figures. The maps were used to illustrate the article on astronomy in the *Encylopaedia Britannica*, both the third British edition (1797) and the first American edition (1798) (Warner 1979, 70).

Thus, there was great activity in celestial cartography in Great Britain from 1650 to 1800, often through association with the Royal Society. Advances were made in the accuracy of star placements, new stars were plotted in the Southern Hemisphere, and constellations were added to depictions of the sky. Cartographers, mapsellers, and globemakers produced and sold their celestial images to navigators as well as to the general public. It is clear that the scientists and mapsellers assisted each other in producing and popularizing celestial maps with the new discoveries for the benefit of the interested general public as well as for the specialist professionals.

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SEE ALSO: Flamsteed, John; Great Britain; Greenwich Observatory (Great Britain); Halley, Edmond

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Celestial Mapping by the Italian States. Observations made with the telescope led to the discovery of new celestial bodies and unexpected details of known ones. Therefore, the desire to record star positions on planispheres and globes joined the desire to produce maps of the moon's surface and the planets. Galileo Galilei was the first to respond in 1610 with his *Sidereus nuncius,* which included engravings of star fields and the moon as seen through a telescope (Friedman Herlihy 2007, 121–22, 126). His work circulated throughout the Italian states: from the Venetian Republic to the Grand Duchy of Tuscany, from the Papal States to the Kingdom of Naples.

Celestial cartography, as an established tradition, was slow to incorporate the results of telescopic observations. Two additional factors explain Italian reluctance to revise celestial planispheres and globes. First, Galileo's condemnation by the Inquisition limited the circulation of Copernican ideas. Therefore, star maps representing the celestial sphere as seen from the exterior (the convex view) were preferred to those representing it from the interior (the concave view). Indeed, the latter representation would insinuate that the terrestrial viewpoint took precedence since stars that are not placed on a crystalline sphere cannot be seen from the exterior. The concave view was rejected especially in works commissioned by those whose political or social power was supported by the Roman Catholic Church. Second, the introduction of telescopic sights into graduated instruments improved the establishment of star coordinates only from the mid-eighteenth century on (Chapman 1990, 12). Consequently, the traditional 1,028 entries of the Ptolemaic star catalog, comprising stars observable with naked-eye graduated instruments only, dominated star cartography.

The effect of Church dogma and the slow dissemination of telescopic observations influenced the production of Italian manuscript celestial globes, usually made by members of monastic orders: Carlo Benci, Amanzio Moroncelli, Giovanni Battista da Cassine, and Pietro Maria da Vinchio (Fiorini 1899, 305–448). Both factors also influenced printed products made for a larger public. For example, in 1687 in Rome, Francesco Brunacci published *Planisfero del globo celeste,* with a convex representation of the constellations and the stars classified in the six Ptolemaic magnitudes.

After he made manuscript globes for the duke of Parma in 1679 and the king of France in 1681–83, Vincenzo Coronelli prepared three editions of celestial globes (108 cm diameter), printed in Paris in 1688 and in Venice in 1692 and in 1699. The second edition (1692) displays the constellations in concave view, revealing that at the apogee of his career Coronelli tried to modify traditional star cartography (Dekker 2004, 178–81). His *Epitome cosmografica* (1693) confirms this modification with its concave planispheres of the northern and southern sky. Nonetheless, Coronelli resurrected the convex representation in the third edition of his globes of 108 centimeters (1699) and in his smaller globe (46 cm) dedicated to William III (1696). As to the stars themselves, Coronelli accepted 73 constellations and 1,880 stars distributed in the six naked-eye magnitudes. Coronelli's followers revived traditional celestial cartography, for example the globe (35 cm) printed in Rome by Giovanni Maria Cassini in 1792.

Despite its influence on cosmology, the Church's condemnation of Galileo did not end telescopic observation. The shape and features of the moon and of the planets were discussed in scientific and aristocratic circles, both secular and religious, and were the subject of artistic representation, as, for example, the *Osservazioni astronomiche* (1711) painted by Donato Creti (Bedini 1994, xvii–xxiii; Galluzzi 2009, 358–59). Italian opticians felt it a point of honor to make telescopes that permitted faithful observation of celestial bodies. In 1646 in Naples, Francesco Fontana published the *Novae cœlestium terrestrivmq[ue] rervm observationes*, offering the astronomical results achieved with his own telescope, and including a detailed lunar map (Fontana 1646, 56–57). Moreover, the rivalry between the instrumentmakers Eustachio Divini and Giuseppe Campani led to the publication of broadsheets that included the representation of the planets based on telescopic observations. Divini's sheet of 1649 shows a carefully engraved lunar map that was reused by Athanasius Kircher in his *Mundus subterraneus* (Kircher 1664–65, 62–63).

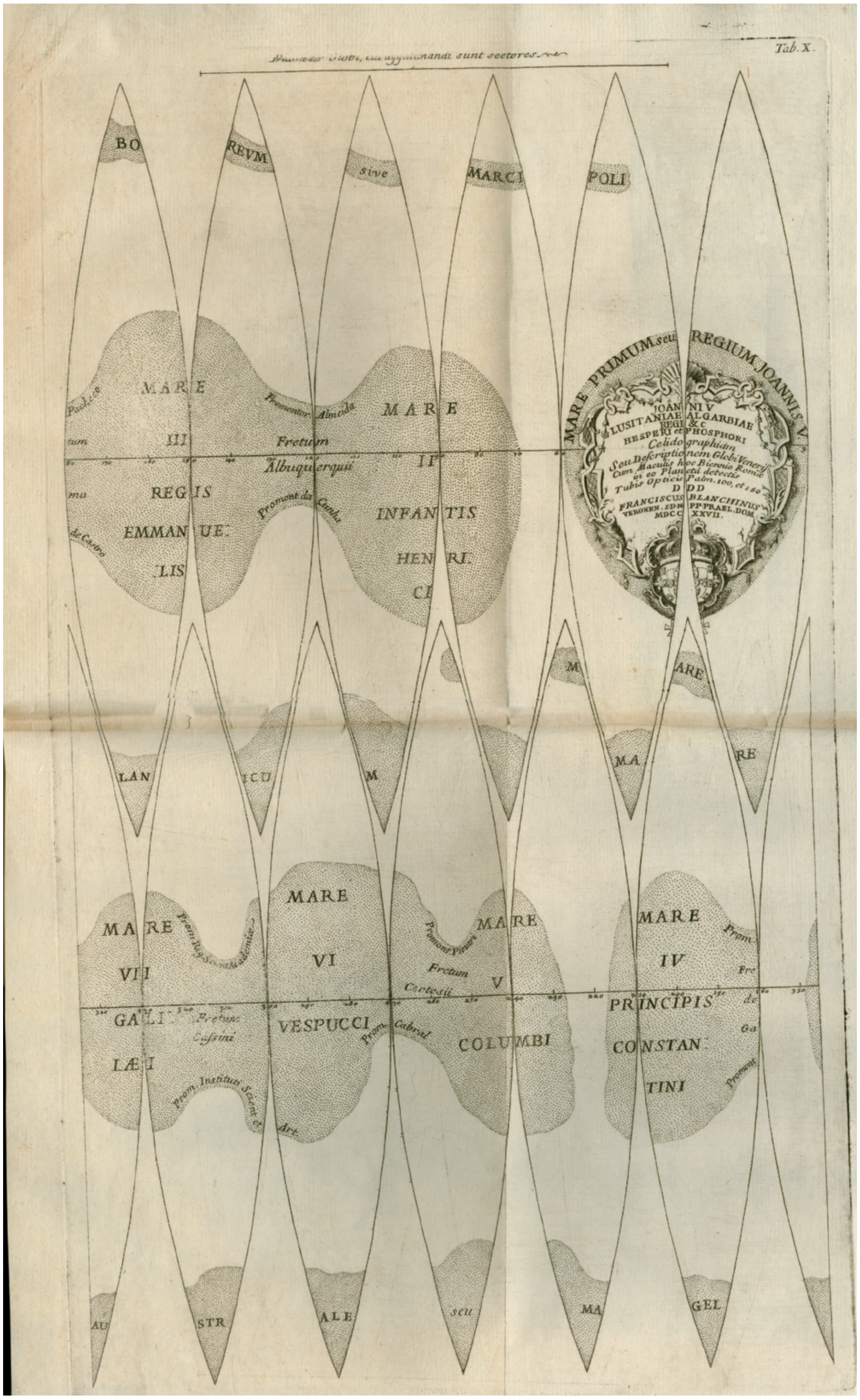

FIG. 168. GORES FOR A GLOBE OF VENUS, PREPARED BY BIANCHINI AND DEDICATED TO KING JOÃO V OF PORTUGAL. The various "seas" are visible across the gores. From Francesco Bianchini, *Hesperi et Phosphori nova phaenomena* (Rome: Joannem Mariam Salvioni, 1728), pl. 10. Realizations of the globe are in the Bibliothèque nationale de France (GE A-295 [RÉS]) and the Osservatorio Astronomico di Bologna.

Size of the original: 55 × 32 cm. Image courtesy of the Special Collections Library, University of Michigan, Ann Arbor.

Because of its earth-like appearance, the moon played a singular role in Italian planetary cartography. Brunacci's 1687 *Planisfero* included images of the planets and a lunar map that synthesized the cartographies of several astronomers, including Giovanni Battista Riccioli and Jean-Dominique (Giovanni Domenico) Cassini (I). In particular, Riccioli's *Almagestvm novvm* (1651) and his *Astronomiae reformatae tomi dvo* (1665) included two noteworthy lunar maps prepared by his assistant Francesco Maria Grimaldi. The first reproduces the morphology of the moon's surface; the second established lunar toponymy still in use (Riccioli 1651, 204–4b, pls.; 1665, 168–69, pls.). Cassini prepared his own celebrated lunar map between 1671 and 1679 based on observations carried out in Paris with Campani's telescopes. This map, engraved by Jean Patigny, was presented to the Académie des sciences in 1679; it was reissued in 1787 and titled *Carte de la lune* (Galluzzi 2009, 373).

Although the cartography of the moon predominated, constant attention was paid to the sun and the planets, until their earthlike appearance was partially discarded. An unusual contribution to this aspect of celestial cartography appears in the *Hesperi et Phosphori nova Phaenomena* (1728) by Francesco Bianchini, which provided instructions for making a small globe showing the surface of Venus as seen through a Campani telescope (fig. 168).

GIORGIO STRANO

SEE ALSO: Coronelli, Vincenzo; Italian States

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Celestial Mapping by Portugal. Celestial mapping by Portuguese authors very much drew upon astronomical activities and research carried out in Portugal in this period. By the middle of the seventeenth century, Portugal, the population of which scarcely exceeded two million, had acquired a vast empire with an economy largely dependent on intercontinental trade. For this reason, training naval personnel was a major concern of the Portuguese authorities. The Aula da Esfera was the main training course for naval cadets. Created around 1574 at the request of King Sebastião and made public in 1590, the classes were taught in the Jesuit Colégio de Santo Antão in Lisbon and covered mainly cosmography, navigation, and geography. As astronomical navigation was an essential tool for successful navigation in the open sea, celestial mapping was frequently discussed by the professors of the Aula da Esfera. In general, these professors focused on describing celestial constellations but rarely used any cartographic representation of them.

Professional astronomers provided a more detailed representation of the arrangement of celestial bodies, especially when comets appeared. As the seventeenth century progressed, astronomical observations and reports by Portuguese astronomers became more accurate, as they increasingly recognized the celestial position and heavenly nature of comets. In addition to locating comets by celestial coordinates, astronomers began to represent the motion of comets using the constellations as a reference system. Though this sort of cartographic representation varied greatly in detail, some reports provided a comprehensive illustration of a comet's motion and the arrangement of celestial bodies. For example, Valentin Stansel, a Bohemian Jesuit in northeast Brazil, represented the comet of 1689 moving south through the constellations of Lupus and Centaurus, away from Scorpius (fig. 169). Such examples of celestial mapping are generally found in manuscript reports of comet observations.

As far as the organization and nature of the heavens was concerned, by the mid-seventeenth century, Portuguese university philosophers largely agreed on the division of the cosmos into three "heavens," the most widespread conception being the *caelum aethereum*, *caelum stellatum*, and *caelum empyreum*. The *caelum aethereum* was conceived as the area between the earth and the supreme boundary of the region where the planets move, the *caelum stellatum* as the heaven comprising the fixed stars, and the *caelum empyreum* as the place of the Blessed. Because the *caelum aethereum* consisted of an *aura aetherea* it was regarded as a fluid heaven. The two remaining heavens were conceived mainly as solid heavens. Jesuit Francisco Soares presented this view in his *Cursus philosophicus* (1651), and the major philosophers followed, including Jesuit António Cordeiro, author of a *Cursus philosophicus conimbricensis* (1714).

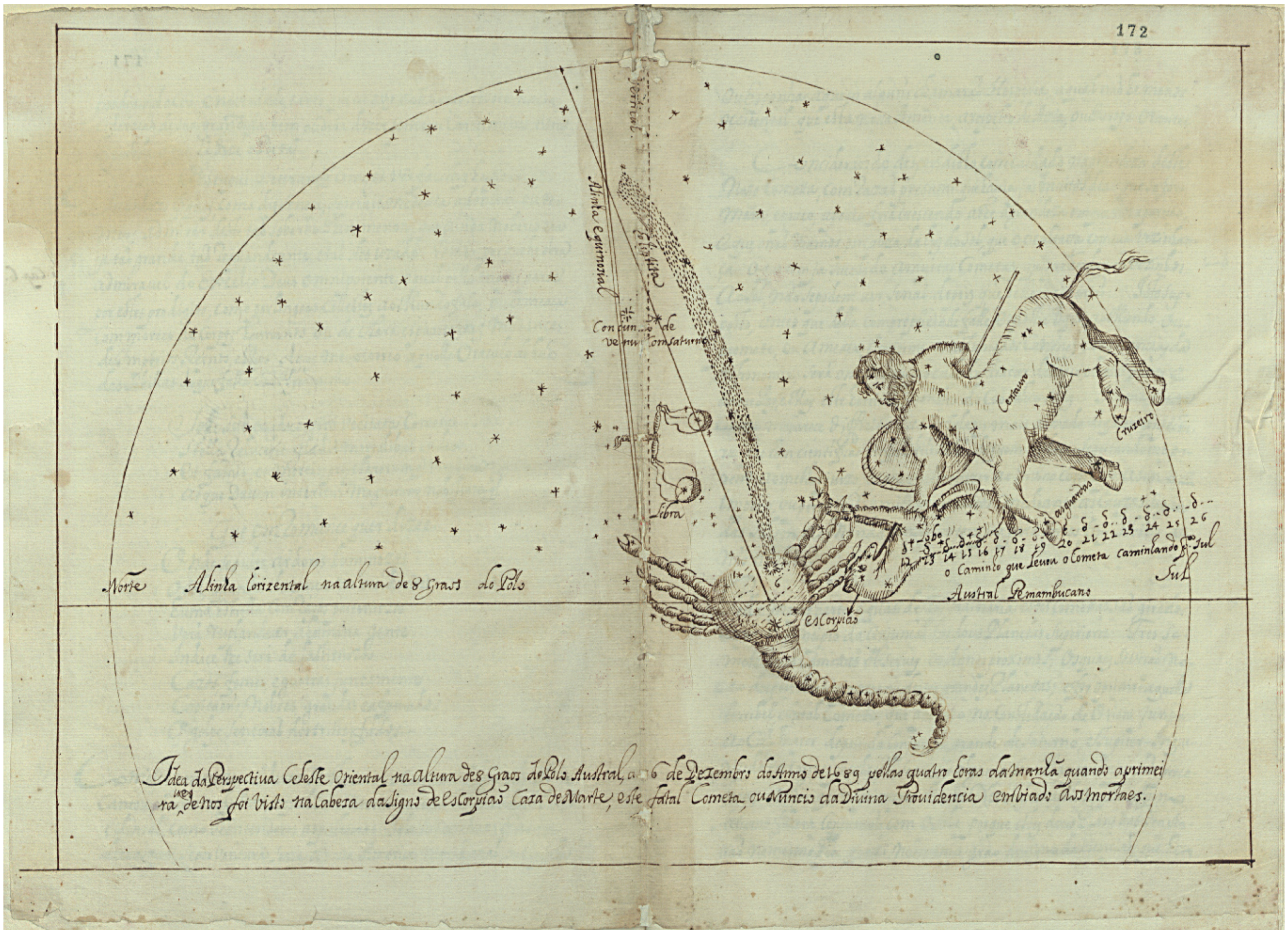

FIG. 169. REPRESENTATION OF THE PATH OF THE COMET OF 1689 BY VALENTIN STANSEL, USING CONSTELLATIONS AS A REFERENCE SYSTEM. Size of the original: ca. 29.5 × 40.0 cm. Image courtesy of the Biblioteca Nacional de Portugal, Lisbon (Manuscritos Reservados, PBA 484, fols. 171v–172r).

Yet the tripartite division was most likely introduced in Portugal by the Italian Jesuit Cristoforo Borri, a professor of mathematics in Coimbra and Lisbon in the late 1620s. In his *Collecta astronomica, ex doctrina* (1631), Borri divided the heavens into *aereum, sidereum* (containing planets and fixed stars), and *empyreum*. In most cases, celestial maps are absent from these philosophical textbooks.

Although Borri associated the tripartite division of heavens with the defense of the astronomical system of Tycho Brahe, university professors of philosophy avoided discussing technical aspects of astronomical models. In the second half of the seventeenth century, they conceived of the earth as immobile in the center of the universe. Most of these philosophers agreed with the Tychonic theory that planets revolved around the sun (and the sun around the earth). As the eighteenth century advanced, philosophers became more receptive to the heliocentric model. Though there is no evidence that a Portuguese philosopher explicitly defended the Copernican system during the eighteenth century, from the mid-1750s onward, chief philosophers agreed that the heliocentric system, as Newton conceived it, was superior on mathematical and physical grounds. Nonetheless, they held to the terms of the Inquisition, and considered the heliocentric model only for purposes of calculation and as a theoretical hypothesis. This was the position held by the Jesuit mathematician Inácio Monteiro in his *Compendio dos elementos de matematica* (1754–56) and *Philosophia libera seu eclectica rationalis* (1766–78), and by the Oratorian Teodoro de Almeida, author of *Recreação filosofica*, an encyclopedia of natural philosophy published in ten volumes between 1751 and 1800. Monteiros's books supply a set of diagrams representing astronomical systems and other information.

LUÍS MIGUEL CAROLINO

SEE ALSO: Portugal

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Celestial Mapping by Spain. Spanish astronomy in the period of the Enlightenment was marked by the participation of Jorge Juan and Antonio de Ulloa in the geodetic expedition to the Viceroyalty of Peru. At Juan's subsequent suggestion, Carlos III encouraged the creation of an astronomical observatory in Madrid similar to those in other European capitals. It was built in 1790 on a little hill in the Parque del Retiro under the direction of the architect Juan de Villanueva. At the same time, a royal decree (19 August 1796) founded a school annexed to the observatory where future astronomers were to be educated, as detailed in royal ordinances published six years later. This novel institution was directed by Salvador Jiménez Coronado, a Piarist abbot who had acquired his scientific knowledge at the foremost European observatories. However, the ambitions of this initial impulse were frustrated by the French invasion in 1808, during which the library, buildings, and equipment were destroyed and the staff dispersed. The damage was irreparable and astronomical activity was not renewed until 1845.

Joseph Garriga y Baucís, a distinguished alumnus of the school, who later became its professor of meteorology, held the chair of Astronomía Syntética del Cuerpo de Ingenieros Cosmógrafos. Soon after his appointment

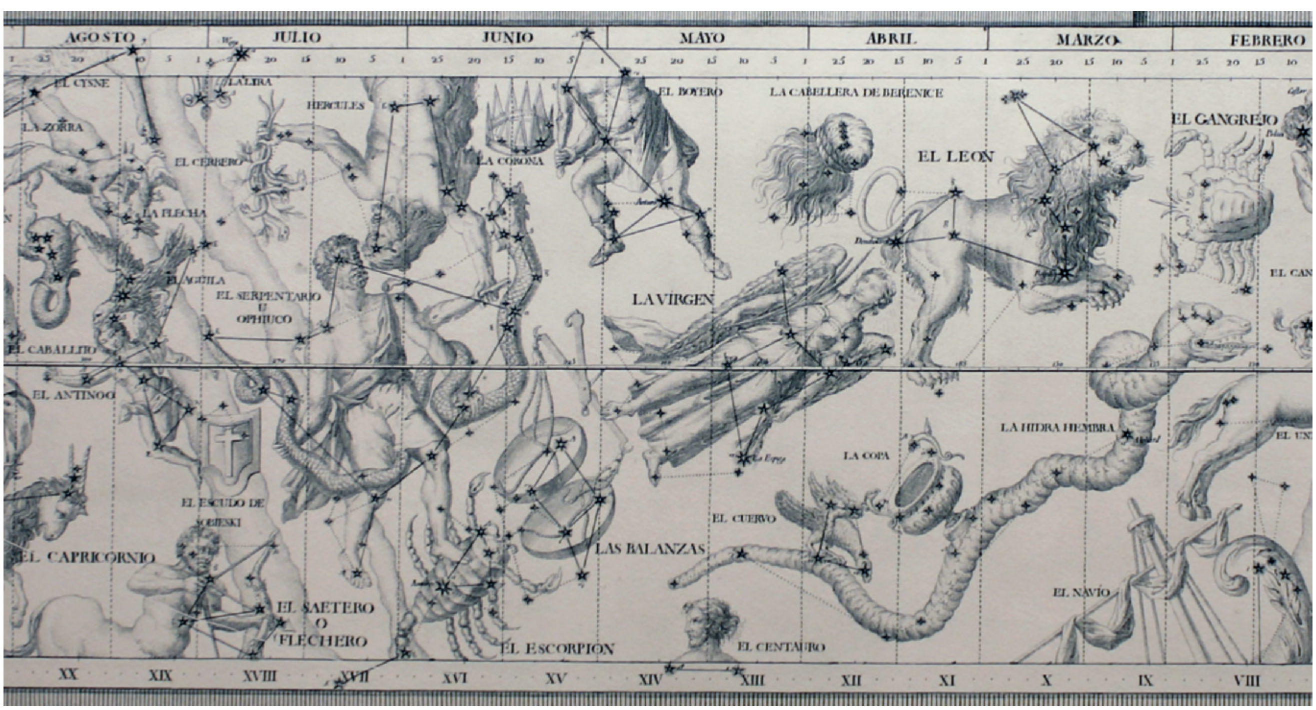

FIG. 170. DETAIL FROM THE RECTANGULAR CELESTIAL MAP BY JOSEPH GARRIGA Y BAUCÍS. Prepared as an illustration for the *Uranografía* (1793), engraving on copperplate. Garriga makes use of the classical allegories of the constellations, especially along the zodiac, but he also includes the geometrical shapes of the constellations that provide a more universal identification. The indisputable artistic value of the work owes to the prestige of the engravers, the brothers López Enguídanos.

Size of the entire original: ca. 46.5 × 103.0 cm; size of detail: ca. 28 × 52 cm. Image courtesy of the Department of Calcografía Nacional, Real Academia de Bellas Artes de San Fernando, Madrid.

he prepared a booklet to complement his classes, *Uranografía, ó Descripcion del Cielo* (1793), inspired by the earlier work of Charles-François Dupuis, a student of the French astronomer Joseph-Jérôme Lefrançais de Lalande and Guillaume Le Gentil, himself a student of Jacques Cassini. Garriga's work advanced some elementary notions of spherical astronomy and analyzed in detail the mythological origin of the classical constellations (especially the figures of the zodiac) and the appearance of the most modern ones. He also drew upon the work of Nicolas-Louis de La Caille for the Southern Hemisphere and adopted the methods of Chrysologue de Gy and Alexandre Ruelle for his graphic presentation of constellations. However, the most striking aspect of the publication was the inclusion of three celestial maps—probably the only Spanish contribution to celestial mapping in the entire eighteenth century. Garriga designed two circular planispheres, one for each hemisphere (each 59 × 49 cm), and a rectangular image centered on the celestial equator, underscoring the position of the zodiacal constellations (fig. 170).

The constellations of the three maps were exquisitely engraved by the brothers Vicente and Tomás López Enguídanos, among the most prestigious Spanish engravers of the period. The maps were not bound in the book, a circumstance explaining their rarity, even in public libraries that possess the book. All three maps are beautifully decorated: the planispheres have circular borders, and the border of the rectangular zodiac map gives prominent position to the royal coat of arms. Garriga arranges the allegorical figures of the hemispheres along a celestial diameter, adding lines to join the stars of each constellation into geometrical shapes, a system that Garriga felt might be easier for the viewer to understand. The legends found in the margins of the maps comprise six symbols for stars of varying magnitude, plus a seventh symbol added for the nebulae. Garriga gave his planispheres a universal character: one could interpret the appearance of the heavens at any given time and place, thanks to the graduated and concentric circles that he placed along the edge of each of them.

MARIO RUIZ MORALES

SEE ALSO: Spain

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Celestial Mapping by Sweden-Finland. In Saami astral mythology, the night sky reveals hunters on skis who chase a wild reindeer (depending on the tribe, the animal may also be an elk, or have golden antlers). This constellation, called Sarva, was composed of Cassiopeia, Perseus, and part of the constellation of Auriga and was sometimes included in the decoration of Saami drums, which typically have cosmological significance (for an illustration of a Saami drum with a reindeer in the "upper world," see Okladnikova 1998, fig. 8.11). The first large-scale introduction to the ethnography of the Saami was the 1673 publication of *Lapponia,* by Johannes Schefferus, a work that included illustrations of Saami drums.

The French expedition of 1736–37 to Sweden's Torne Valley, led by Pierre Louis Moreau de Maupertuis, brought astronomers into contact with the Saami people. One of the participants in the expedition, Pierre-Charles Le Monnier, was inspired to add a reindeer ("le Réene") to the traditional Western canon of constellations in a star chart he published in his *La theorie des cometes* (1743). Le Monnier's reindeer was a small and faint asterism between Cassiopeia and Camelopardalis, and not the huge conglomeration that represented Sarva, but it was quickly adopted by Swedish and other astronomers.

In 1758 a cosmographical society, the Kosmografiska sällskapet, was founded in Uppsala with the goal of publishing treatises and starting the manufacture of globes. Three volumes were eventually published by the society, under the general title *Werldsbeskrifning* (1766–72), including the *Allmänn eller mathematisk beskrifning om jordklotet,* by the astronomer Fredric Mallet and the *Physisk beskrifning öfver jord-klotet,* by the astronomer and geographer Torbern Bergman. In 1762, Mallet published a booklet on globes in which he alluded to the use that Maupertuis's expedition had made of reindeer. Mallet endorsed the idea, from Le Monnier, of adding a reindeer constellation to the firmament stating that "the docile reindeer of the natives were worthy of a place in the heavens between the Little Bear, Cepheus, Cassiopeia, and the Camelopard" (Mallet 1762, 3n.c). The Kosmografiska sällskapet's books contained no maps, but as early as 1759, Anders Åkerman, another member of the cosmographical society and the copper engraver for the Kungliga Vetenskaps-Societeten i Uppsala, produced a pair of globes (the first to be published in Sweden) with a diameter of thirty centimeters. The celestial globe proudly showed the new reindeer constellation, now named "Reno." Åkerman also produced a pair of globes with a diameter of fifty-nine centimeters in 1766 and a pocket globe of eleven centimeters diameter was sold in 1762 (fig. 171).

Åkerman's Uppsala workshop suffered a fire in 1766, after which it moved to Stockholm. After Åkerman's death in 1778, globes continued to be manufactured under his name up to 1824. The reindeer constellation was accepted by John Flamsteed in 1776 and by Johann Elert Bode in 1782, and it appeared in the latter's celestial atlas. Although it continued to be shown on some celestial maps in the nineteenth century (and even into the twentieth century, e.g., Seth Zetterstrand and Karl D. P. Rosén, *Nordisk världsatlas*, 1926]), the Finnish astrono-

FIG. 171. DETAIL FROM ANDERS ÅKERMAN, COPPER-ENGRAVED GORES FOR A CELESTIAL GLOBE, 1762. Segments of the Southern and Northern Hemispheres with a reindeer ("Reno") at the top of the third gore from the left. Size of the entire original: 15 × 36 cm; size of detail: 10.4 × 8.8 cm; each gore: 8.5 × 2.9 cm. Image courtesy of Kungliga biblioteket, Stockholm (KoB S Qv Br 29 HG 1762 11 cm).

mer Fredrik Wilhelm August Argelander omitted it from his authoritative catalog of constellations (*Uranometria nova,* 1843).

ULLA EHRENSVÄRD

SEE ALSO: Sweden-Finland

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Chabert, Joseph-Bernard, marquis de. Joseph-Bernard, marquis de Chabert, was born in Toulon on 28 February 1724. Having entered the *gardes-marine* in July 1741, he participated in numerous campaigns and attained the rank of *enseigne de vaisseau* in April 1748. Interested very early in nautical science, he was sent in 1750 to the northeast coast of North America on an astronomical and cartographic mission; the published results established his scientific reputation (fig. 172) (Chabert 1753). His publication was the first work to receive the approbation of the Académie de marine, founded the previous year (1752) and of which Chabert was a member. *Lieutenant de vaisseau* in February 1756, he held command in the engagement before Port Mahon (Minorca) on 20 May of that year, before being elected on 3 September 1758 to the Académie royale des sciences. He was named *inspecteur adjoint* of the Dépôt des cartes et plans de la Marine on 20 October 1758. From 1753, he had planned to produce a second volume of *Le Neptune françois*, presenting his plans to the Académie des sciences in 1759 (published, 1766), but this project remained incomplete. Because of the Seven Years' War, Chabert could not conduct his first full Mediterranean cartographic mission until May 1764, although he had made observations in Spain and the eastern Mediterranean from 1753. He was promoted to *capitaine de frégate* in October 1764, then *capitaine de vaisseau* in November 1771. He divided his time between the Dépôt and the Mediterranean until 1778, but hydrography was secondary during these navigations, which were concerned mostly with war and protecting commerce. Under these conditions, he was never able to complete any surveys with triangulation on land, despite his interest. He contented himself with measures of longitude by marine clock, an instrument Chabert thought fewer than ten officers were capable of using for hydrography (i.e., less than one percent of those active around 1775) (Chapuis 1999, 306). During the American Revolutionary War, in which he commanded warships (1778–82), he was responsible for calculating the longitude of the squadron with marine clocks. His text on the subject prefigures modern pedagogy regarding astronomical navigation (Chabert 1785, 4–5; Chapuis 1999, 306). He also authored the *arrêt* (decision) of the Conseil du Roi on 5 October 1773 that established true supervision over hydrographic production and the principle of transparency of sources. He was promoted to *inspecteur* (or director) of the Dépôt on 10 May 1776.

Although the marquis was, from 1748, a true precursor of the new methods of calculating longitude, a faithful promoter of marine clock making (Chabert 1785), and the head of the Dépôt (albeit with a mixed record, having failed in the effort to launch the project for a "Nouveau neptune françois"), he tended to oversim-

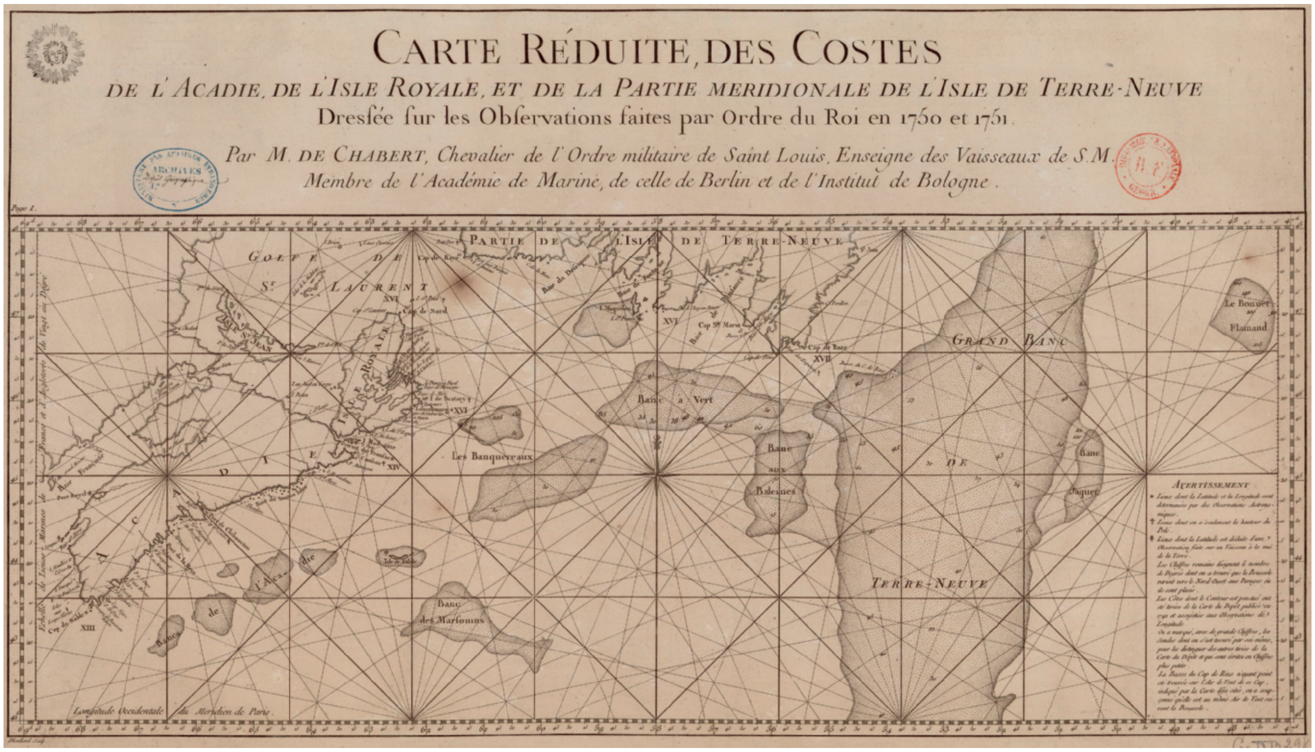

FIG. 172. JOSEPH-BERNARD, MARQUIS DE CHABERT, *CARTE RÉDUITE DES COSTES DE L'ACADIE, DE L'ISLE ROYALE, ET DE LA PARTIE MERIDIONALE DE L'ISLE DE TERRE-NEUVE* (PARIS, 1751). First edition, engraved map in one sheet, ca. 1:3,000,000. On an astronomical and cartographic mission in 1750 along the northeast coast of North America, Chabert established his scientific reputation by using the land-based technique of triangulation, combined with compass bearings, marine clocks that were in the process of being verified, and lunar distances. He emphasized notably the differences in longitude positions of up to nine degrees for the east coast of Newfoundland as against those found on contemporary European maps.
Size of the original: ca. 32.5 × 58.5 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 2987 [8596]).

plify the problems of hydrography by reducing them to a matter of nautical astronomy only. His personal cartographic work was thus very limited: of the 127 maps engraved under the supervision of the Dépôt between 1737 and 1772, he himself prepared only one. Created *vice-amiral* on 1 January 1792, Chabert emigrated to England a few months later, and did not return to France until 1802, when he immediately retired with a pension until his death in Paris on 1 December 1805.

OLIVIER CHAPUIS

SEE ALSO: Dépôt des cartes et plans de la Marine (Depository of Maps and Plans of the Navy; France); Longitude and Latitude; Marine Charting: France

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Chart. See Marine Chart

Circumferentor. See Instruments for Angle Measuring: Circumferentor

Cities and Cartography. In considering the graphic visualization of the city in the period of the Enlightenment, one might argue that the eighteenth century closed rather sooner than chronological dates would suggest. The period witnessed an anxious struggle to resist the demands of scientific topography and to oppose the demise of the traditional city view.

The iconography of urban depiction from ca. 1650 to the end of the eighteenth century elicits a number of themes. Along with city views clearly intended for celebration, other concurrent urban images were increasingly concerned with the quality of topographical depiction. All the major cities of Europe produced such maps for military, fiscal, and urban-planning purposes. The first surveys of urban topography were performed with scientific instruments whose use was standardized in contemporary treatises. The political and ideological aims behind these images pushed them to be as extensive and as complete as possible, hence the choice of special points of view from which it was possible to capture the full spectacular potential of the *forma urbis,* as has been fully treated in *The History of Cartography*, volume 3.

In the later sixteenth and early seventeenth century many cities were the subject of large multisheet engraved urban views. The centers of production for such works emerged in Amsterdam, Lyons, Paris, Rome, Venice, Frankfurt, Basel, and Cologne, to name a few. The Italian lead in this field was beginning to wane, as dynamic schools of topography grew in the Low Countries and in many German-speaking cities. But whether painted or engraved, the urban view was the fruit of interaction between a simplified visual code and a graphic language specific to figurative culture. Each view—especially those engraved on copperplates—was accompanied by various texts: dedications, titles, subtitles, indices of monuments or topographical features, and explanatory captions of varying length. Some maps indicated only the *mirabilia* of the city, while others covered both the most noteworthy structures as well as streets, squares, districts, seats of power, manufacturing facilities, services, and infrastructures. Many sixteenth- and seventeenth-century urban views were accompanied by brief accounts of the city's history, a feature totally absent from fifteenth- and eighteenth-century views. Often decorated with mythological or allegorical figures, the sheets also contained compass indications and notation of scale.

During the course of the seventeenth century, dedications and explanatory texts lengthened and grew more detailed, sometimes including not only the names of those who commissioned, drew, engraved, and printed the map, but also describing its purposes. Occasionally they contained information about the time required to make the map and the methods used.

For quality, size, and engraving technique, one of the most interesting such iconographical documents dating from the end of the sixteenth century is the large *Recens provt hodie iacet almæ vrbis Romæ cvm omnibvs viis ædificiisqve prospectvs accvratissime delineatvs* (1593) drawn by the Florentine painter Antonio Tempesta. The view celebrates the Rome of Sixtus V, even though it is dedicated to his successor Clement VIII. Tempesta's plan records all the building projects and urban plan reforms realized during the pontificate of Sixtus V by the architect Domenico Fontana. He constructed a rather complex perspective view of the city, seen from an ideal point located a long way above the Janiculum Hill. However, the contractions and distortions in his rendering of the core of the city are so obvious that one must consider this point of view as only one among many used constructing Tempesta's *Prospectvs.* In all probability, Tempesta took Leonardo Bufalini's 1551 map as a starting point, though he used this frame of reference so freely that he compromises its topographical accuracy. Tempesta's view, in fact, so distorts the length and width of the major streets that topographical precision is undermined. As Daniela Stroffolino has shown, in such cases the use of such "shortcuts" is the result of—in some way, the inevitable result of—the complexity of the urban morphology (Stroffolino 1999).

The two main approaches to the depiction of cities in our period were the perspective or urban view and the urban plan. City views of Amsterdam reveal a constant striving for an effective blend of apparently contradictory features of urban representation: the combination of the figurative and the abstract, the scientific and the artistic, the practical and the celebratory. Two types of depiction dominate: the perspective plan (a ground map with an axonometric elevation) and the profile view of urban fabric (particularly appropriate for a city like Amsterdam whose *genius loci* is the reflection of buildings in water). During the early seventeenth century the number of large-scale profiles of the city as seen from the sea increased. *Amstelodami emporii totius orbis celeberrimi*, published in 1618 by Pieter van den Keere, offers an excellent example of the all-embracing and extensive view of the city which was, of course, impossible in real life. The artist assembled the final version of the image in his studio, basing his work on partial views taken on site, his mobile viewpoint from a boat moving slowly along the coast.

Dutch artists and cartographers combined the precision of a measured survey with a high level figurative effect, as revealed by the work of Amsterdam artist and printer Claes Jansz. Visscher. His isometric view of Amsterdam presents an image of the city simultaneously viewed from all sides, made possible by skillfully combining isometric elevation—a document that records the contemporary plan for massive urban expansion—and a flat profile illustration, complete with views into the urban fabric of the city (fig. 173). This unusual combination of plan and city view was known in Dutch as a *caert figuratief* (figurative map) and would enjoy great success in other cities of North Europe, offering a sort of visual encyclopedia—or, better "an encyclopedic image of the city" (Bakker 1996, 88).

The distance between descriptions and maps with axonometric elevations would increase through the seventeenth century, just as the divide grew between painted

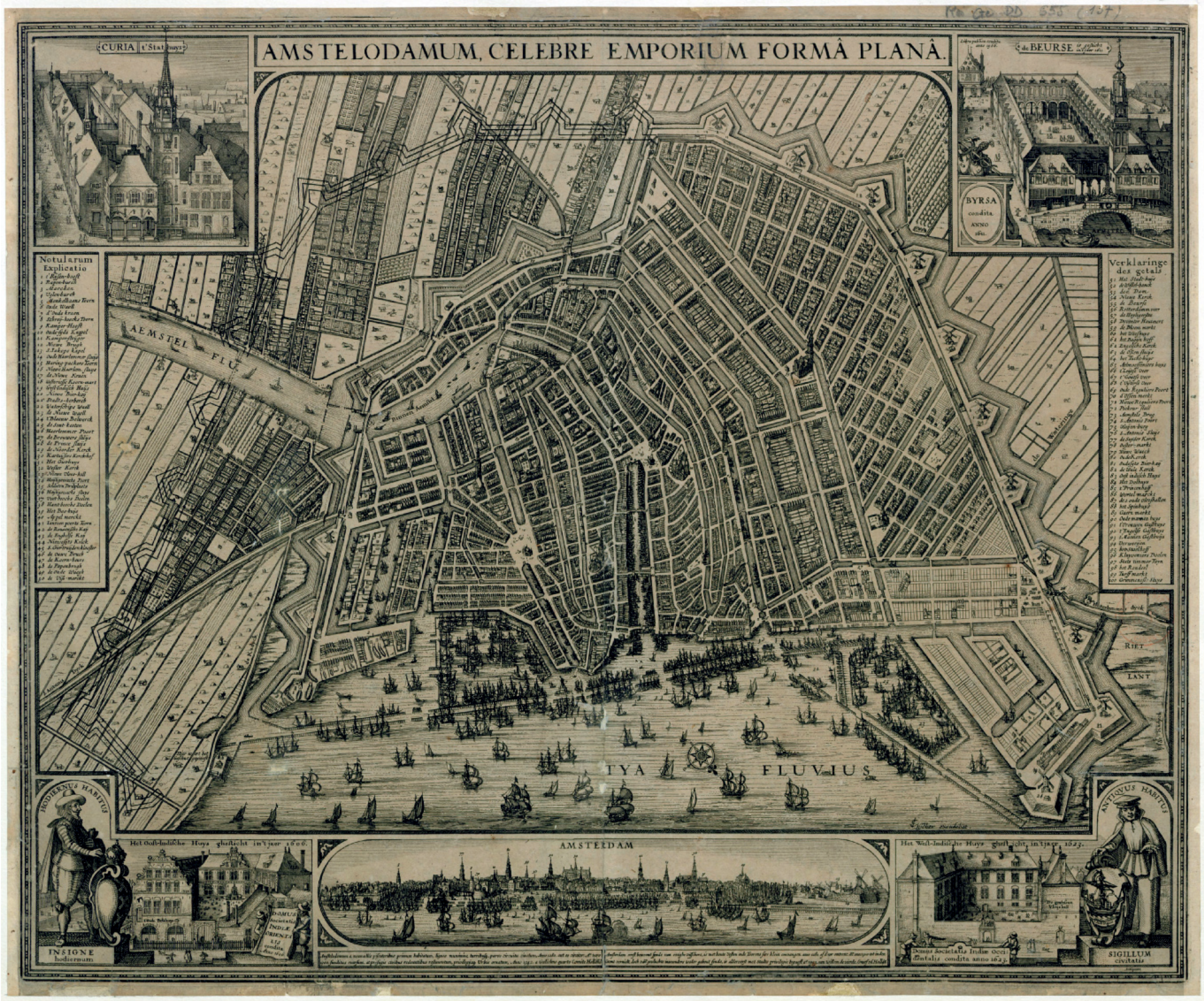

FIG. 173. CLAES JANSZ. VISSCHER, *AMSTELODAMUM CELEBRE EMPORIUM FORMÂ PLANÂ*, CA. 1623. Visscher's axonometric view of Amsterdam incorporates both a profile view of the city with elevations of important civic buildings: the Council house, the Bourse, and the two buildings of the Dutch Vereenigde Oost-Indische Compagnie (VOC), built in 1606 and 1623. Scale 1:7,250.
Size of the original: 47.5 × 57 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge DD 655 [137] RÉS).

(or drawn) city views and engravings inspired by topographic survey. However, the latter approach did not establish the model for the depiction of a city. In Naples, for example, the relation between painting and topography was inverted: Alessandro Baratta's monumental *Fidelissimæ vrbis Neapolitanæ cvm omnibvs viis accvrata et nova delineatio* (first edition, 1627) established a model that would only later be given more popular expression by the talented artist Didier Barra, whose most important painting of the city dates from 1647. Baratta's view constituted an iconographic prototype of exceptional importance for European urban iconography, variously replicated until the end of the eighteenth century. In this case, the preparatory designs have come to light: a circumstance as unique as it is rare, which provides us with precious information on the technical means by which Baratta produced the view (Baratta 1986).

England contributed much less to the iconography of urban representation, lacking independent city-states eager to advertise and celebrate their glories in "self-portraits." However, the trend changed in the wake of engraved views published in neighboring Netherlands, which led to a boom in urban depiction within the Anglo-Saxon world. As in Holland, two methods of urban representation developed: the urban plan and the urban view.

Clearly, the seventeenth-century city portraits of the Renaissance were constructed using the central, bipolar, and multipolar perspective models that were part of the renovated concept of non-Euclidean space. However, in tracing the history of the city portrait one cannot ignore the innovative contribution of both landscape painting and scientific topography. These twin influences were at work during the seventeenth century, with the heightened tension between them ultimately being resolved during the eighteenth century by the irreconcilable divorce between art and science. The eighteenth century itself was the period when topography became a science of observation and measurement with its own increasingly specialist literature; at the same time, much of this literature taught the artistic skills of rendering landscape and three-dimensional shapes onto the two-dimensional plane.

Comprising twenty plates forming a whole measuring more than 3 × 2 meters, the *Plan de Paris* (1739) is in many ways the view of Paris par excellence (fig. 174). A portrait of one of the world's most beautiful cities during a flourishing period in its history, the work employed a full range of technical and artistic means to achieve its extraordinary evocative power. The most seductive of all cartographic representations of Paris, it could be read and by one and all, enabling each one of us to "visit" the city. In effect, Louis Bretez, the artist-topographer who created it, did more than merely meet the requirements of the—perhaps perfect—city plan. He offered us a perspective view that enables the eye to wander enjoyably around the city's monuments, gardens, squares, boulevards, suburbs, churches, and *hôtels particuliers*. In the first decades of the eighteenth century, Paris still did not have perspective views that could rival those that had depicted Venice, Genoa, Rome, and Naples in the sixteenth and seventeenth centuries. But if Paris was a latecomer to city portraiture, it made up splendidly for lost time. Like all the great city views, that of Paris

FIG. 174. LOUIS BRETEZ, *PLAN DE PARIS,* 1739, SHEET 6. The perspective plan of Paris was surveyed and compiled by Bretez, engraved by Claude Lucas, and printed on twenty sheets, creating an imposing wall map. Bretez surveyed the city under the orders of Michel Étienne Turgot, provost of the merchants' council in Paris. Size of the sheet: ca. 51.0 × 79.5 cm. Image courtesy of the Stephen S. Clark Library, University of Michigan, Ann Arbor (G 5834.P3A3 B6 1739).

was inspired by the desire to celebrate the city, to glorify its beauty and prosperity; such was clearly the aim of Michel Étienne Turgot, head of the city's council of merchants and sponsor of the *Plan de Paris*.

The Bretez perspective view was preceded in 1716 by the *Plan de la ville et fauxbourgs de Paris* by Guillaume Delisle, who, as an astronomer and geographer, was interested less in the celebration of the city than in determining its precise size and dimensions on the face of the earth (see fig. 893). His use of triangulation techniques on the ground along the Paris Observatory's meridian and his compilation methods in the office produced a geometric plan based on observed fixed points (Boutier 2008).

Starting from a geometrical plan, Bretez set about drawing axonometric depictions of all the buildings and structures that made up what was then the largest and most populous city in the West. Having pieced together this puzzle, he then passed on to the engraving phase, commissioning a team of specialists who would magnificently reproduce the drawings in etched copperplates.

By the middle of the eighteenth century, the abovementioned split between science and art had become an irreconcilable divorce. Evidence of this can be seen in Giovanni Battista Nolli's monumental *Nuova pianta di Roma* (1748), which incorporated a series of urban views drawn and engraved by Giovanni Battista Piranesi (see fig. 609). It was, apparently, no longer possible to depict the contemporary city from a (perhaps mobile) point of view in space, even if this ambition would lead to the emergence of the panoramic view toward the end of the century. However, before the advent of such panoramas—the ultimate act of homage to the city portrait—the European city had become fragmented into various parts.

Giovanni Carafa, duca di Noja, is a typical representative of a culture that would appear to have moved beyond the old dichotomy between humanism and science. His analysis is scientific in nature and character, just as the solution that he offers arises from a method proper to the sciences: he sought to measure the real size of the city and to create a topographical record of the geology and natural features of the terrain running from Mount Vesuvius to the Phlegraean Fields. He had kept apace with recent topographical techniques, and his skill was well demonstrated in the monumental *Mappa topografica della città di Napoli*, to which he would dedicate twenty-five years of work, printed on thirty-five sheets in 1775 (see fig. 880). The topographical plan offers a basis for reordering of the city as an indispensable instrument for restoring the proper and effective administration of justice and maintaining public order. In short, it is essential for implementing a range of projects, including sewers and the provision of water supplies. Given its truly unusually large size (4.85 × 2.20 m), the quality of its engraving, and the accurate detail of its topography, Giovanni Carafa's map may be considered one of the most important cartographic undertakings of the century. Its inclusion of the *veduta scenografica*, a skillful rendering of the city nestled within the bay, also gives this document exceptional historical interest. The work may be said to be the magnificent final achievement of eighteenth-century *vedutismo* at the same time as it marks the advent of the new tradition of scientific topography.

The eighteenth century was the century during which topography was confirmed as a science: geographers, topographers, and astronomers developed working methods ever more specialized and used ever more sophisticated techniques. The great cartographic enterprises begun by Felipe II and Louis XIV during the sixteenth and seventeenth centuries did not yet see the divorce between the art of the view and the science of topography; only in the course of the century of the Enlightenment was this separation consummated in a clear and definitive way. There naturally remained an ambiguous territory that art and science continued to cohabit: thus the view makers used topographical instruments, and topographical and astronomical geographers did not forsake completely using the charm of the view (De Seta and Stroffolino 2001, 11–56).

CESARE DE SETA

SEE ALSO: Administrative Cartography; Nolli, Giovanni Battista; Urban Map; Urban Mapping; Urban Planning and Cartography

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Climate Map. See Thematic Map: Climate Map

Colbert, Jean-Baptiste. Born in Reims in August 1619, Jean-Baptiste Colbert belonged to a long line of successful merchants. He attended the Jesuit college in Reims before his father, Nicolas Colbert de Vandières, left the

FIG. 175. DETAIL FROM VINCENZO CORONELLI'S TERRESTRIAL GLOBE PREPARED FOR LOUIS XIV, PRODUCED FOR THE MOST PART BETWEEN 1681 AND 1683. Paint on cloth about four meters in diameter. The area shown is between 30° and 60° south latitude, with representations of the four parts of the world: on the left, Europe discovers America; in the middle, a rich and receptive Asia awaits French vessels; on the right, Africa accompanied by animals evokes the labors of the Académie des sciences.
Size of the detail: ca. 230 × 275 cm. Paris, Bibliothèque nationale de France (Cartes et plans, Ge A 500 RÉS).

fabric trade to move to Paris. Jean-Baptiste Colbert learned law and finance by working. As *commissaire ordinaire des guerres* in 1640, he gained an appreciation of terrain and probably a taste for maps as he supervised the quartering of troops. In 1661, he began to serve Louis XIV. Over the years, he became—to adopt modern terminology—minister of finance, industry, and commerce; minister of culture; and minister of the navy and colonies and thus kept the king informed of all state business. He played a major role in the transformation of Paris, where he died on 6 September 1683.

During 1663–64, Colbert planned to collect all existing maps of France and have them corrected in order to know precisely the boundaries of all its administrative divisions (Trénard 1975, 69–82). This project has to be linked to the partially completed investigation of the economic state of France; it encouraged the 1665 memoir attributed to Nicolas Sanson (Pastoureau 1982, 152–53). Colbert was the moving force in the creation of the Académie des sciences, whose founders assembled in his library in June 1666. The Académie began to study the methods used for cartographic surveys, and in 1668 Colbert charged them with determining the best methods. It was to Colbert that abbé Jean Picard submitted the plan for the general triangulation of France (not completed until 1744), which Picard deemed indispensable for the execution of all cartographic works and for the exact knowledge of the dimensions of the globe.

Without waiting for the results of these scholarly efforts, Colbert used maps to execute the reforms he had taken up: manuscript plans for improving the administration of the royal forests (Hervé 1960) and marine maps, partially edited in *Le Neptune françois* (1693), to assure the security of the *renaissante* navy. Although Colbert's projects were vast, he closely supervised them. For example, in 1671, he demanded that one of the *ingénieurs* of *Le Neptune françois* accompany his cartographic surveys with certificates drawn up by the pilots, mariners, and principal officers of the places mapped (*Colbert* 1983, 107–8). The interest shown by Colbert in cartography and the maritime expansion of France certainly involved him in the construction of the great globes of Vincenzo Coronelli (fig. 175), destined originally for the château of Versailles and still testimony to the "old" cartography that the Académie des sciences was about to renew (Pelletier 2012, 26–33).

MONIQUE PELLETIER

SEE ALSO: Academies of Science: Académie des sciences (Academy of Sciences; France); Administrative Cartography: France; Economy, Cartography and the; France

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Color and Cartography. Color has long played a significant role in cartography (Woodward 2007, 602–6). Manuscript mapmaking has a long history of including color as one of its basic tools in the form of pigments, leads, and inks, all of which lend meaning and clarity to the map. Printed maps have used added color to decorate, emphasize, and identify; experiments with color printing have furthered these trends. This essay explores the relationship between color applied to the more familiar printed maps (usually medium- to small-scale geographic maps prepared for a commercial market) and color on manuscript maps (usually prepared at large scale for property delineation, military objectives, or administrative projects).

The study of color on printed maps between 1650 and 1800 reveals three patterns. The first is a shift from a clear domination of printed Dutch cartography in the seventeenth century to the dissemination of a more generally European cartographic production in which Germany, France, and Great Britain played increasingly important roles. Testifying to this shift are the copying and sales of maps by French mapmakers such as the Sanson family, Alexis-Hubert Jaillot, Nicolas de Fer, and Guillaume Delisle and the establishment of solid editorial houses like Seutter and Homann in Germany (Hofmann 1998). The second pattern was the technical innovation of copperplate engraving, which uses both the engraving burin and etching needle. While woodcut printing ensured a large diffusion of maps, engraving on copper allowed for an even larger number of impressions that usually left the printer's shop in black and white. Except for the few experiments in color printing with copper, in most cases color was applied by hand after printing. The third pattern involving color centered on the evolution of the aesthetics of the map. Slowly the Dutch aesthetic, which emphasized decoration and iconography, was succeeded by a more spare aesthetic reflecting exactitude and verifiability as seen through the transition from the monster-filled map to the blank spaces on maps (Jean-Loup Rivière in *Cartes et figures de la terre* 1980, 135).

In the middle of the seventeenth century two styles of coloring, or illumination, on printed maps existed side by side. The first, typical of the Flemish style, used pigments mixed with white lead in order to obtain an opaque color, resulting in lively shades, sometimes varnished, but that risked covering up printed details of the maps and did not age well. The second method, characteristic of Dutch maps (*à la manière hollandaise*) used less pigment and no white in order to achieve a transparent color with delicate shades that allowed the engraving detail to show through the color (Hofmann 1999, 37).

During the eighteenth century there developed two methods of applying color to maps: illumination (*enluminure)* and watercolor wash (*lavis)*. Illumination was used to emphasize a preexisting design already printed on the map (fig. 176), while watercolor washes were employed to add information to the plan or the map. However, this distinction was very theoretical, and in practice these two types of map coloring rested on national traditions. Full color on maps corresponded to German practices consisting of coloring in full the various zones of a map such as administrative regions, religious areas, countries, or empires (fig. 177). This principle may have been fixed by the introduction to the *Museum geographicum* (1726) of Johann Hübner. Hübner specified outright that the use of color should be limited to significant elements on the map, explicitly excluding the cartouches and other ornaments (Hofmann 1998, 91). Coloring along lines, very much in the French tradition, consisted of avoiding any color in full and only outlining the limits or boundaries with color of various widths. These distinctions, though useful for making general statements, were not always clear among the mapmakers of the day, yet they provided the vocabulary necessary to discuss and advertise maps when they were produced.

FIG. 176. DIDIER ROBERT DE VAUGONDY, *TURQUIE D'ASIE, ARABIE, PERSE, TARTARIE INDEPENDANTE,* 1761. Map showing outline *enluminure,* a light application of color added to emphasize the existing boundaries printed on the map, typical of most French and English printed cartography of the eighteenth century. From the *Nouvel atlas portatif* (Paris, 1762), number 35.
Size of the original: 24.3 × 22.0 cm. Private collection.

The cost of coloring may be discerned from the price of colored maps. The 1662–65 Latin edition of Joan Blaeu's *Atlas Maior,* comprising eleven volumes and 593 maps, one of the most expensive printed works of the seventeenth century, was offered in black and white for 350 guilders and in color for 450, reflecting a 30 percent markup in price. One hundred years later, *Le Petit atlas maritime* of Jacques-Nicolas Bellin (1764) sold for ninety-six livres unbound and uncolored, 120 livres half bound with the seas in full wash, or a 25 percent increase (Pedley 2005, 69). For atlases and books, the difference between black and white and color depended on what constituted a beautiful book and the quality of its binding. Thus in 1762, Jean Lattré, a geographic engraver and publisher, sold an *Atlas maritime,* which he offered "bound in Morocco leather and watercolored, 15 livres; bound in calf, without color, 9 livres" (*Mercure de France*, July 1762, 1:159–61). Similarly, in Amsterdam ca. 1705, the firm of Covens & Mortier offered its *Atlas nouveau* comprising 166 Sanson and Jaillot maps in the following range: uncolored, 103 florins; illuminated, 117 florins; doubly illuminated, 130 florins; with cartouches and ornaments illuminated, 164 florins; very beautifully illuminated with additional gold, 195 florins (Van Egmond 2009, 229).

For single maps, contemporary advertising detailed the price differences between color and black and white. Georges-Louis Le Rouge in Paris increased the price of maps 40–50 percent for added color (*lavée)* (Hofmann 1999, 43). There were other variables in the materiality of the map that also explain these differences: the application of color could require a different sort of paper. In 1749, a map titled *Attaques, plan & environs de la ville d'Ypres* sold for "35 sous printed on paper prepared and beaten for watercolor wash . . . 30 sous on ordinary paper" (*Mercure de France,* September 1749, 173). Beaten paper allowed the owner to apply color.

The price differences between the printed map with and without the application of color emphasizes two separate phases of production. Coloring was carried out by an *enlumineur* or a *laveur* (colorist) who was not necessarily specifically trained but was connected to the map or print trade and often female (Le Bitouzé 1986, 51–53). As with the illumination of art engravings, cer-

FIG. 177. MATTHÄUS SEUTTER, *MAPPA GEOGRAPHÆ NATURALIS SIVE TABELLA SYNOPTICA*, CA. 1730. Scale: ca. 1:850,000 (hypothetical, since no real place is depicted). The map employs a light watercolor wash applied over the printed area. This method was used extensively by the two German publishing houses of Seutter (Augsburg) and Homann (Nuremberg).
Size of the original: 47 × 55 cm. Image courtesy of the E. D. Chase Pictorial Collection, Harvard Map Collection Digital Maps.

tain authors perceived the coloring of maps as an amateur activity, as demonstrated by *A Book of Dravving, Limning, VVashing or Colouring of Maps and Prints, and the Art of Painting* (1660). The *Ecole de la mignatvre* (1673 and regularly reedited until 1817), described illumination as carried out by nuns or "persons of quality" (nonprofessionals of independent means) living far from the capital and desiring a useful activity (Boutet 1673, vi). Its translation into Dutch by P. J. Verly in 1744 contained a supplement regarding the illumination of plans that the first French edition did not contain: "De manier van de plans te wasschen" (Verly 1744, 130–38; Bosters et al. 1989, 107–8), giving specific instructions for map coloring. Such manuals were aimed at a genteel market. John Smith similarly added a chapter for map coloring, "A Discovery of the Mystery of Back Painting Maps or Prints" to his popular book, *The Art of Painting in Oyl* (1687, 2d ed.). The art of limning, or illuminating by outline and color, encouraged a continuous flow of instruction manuals throughout the long eighteenth century, with titles such as William Salmon's *Polygraphice; or, The Art of Drawing, Engraving, Etching, Limning, Painting, Washing, Varnishing, Colouring, and Dying* (1672), and Willem Goeree's *Verligterie-kunde of Regt gebruik der water-verven* (1668; reedited 1670, 1697, 1705), which attributes a color to every sort of object to be represented on the map (Bosters et al. 1989, 105–6). All these books bolstered amateur practice in map and print coloring.

Not all maps were colored by members of the reclusive gentry. The Homann firm in Nuremberg employed as many as thirty colorists to illuminate their map products, which were rarely sold uncolored (Heinz 2002, 102). In London, the mapmaker Thomas Jefferys's apprentice, John Lodge, established himself specifically as a map print colorist (*Public Advertiser,* 20 October 1761), an occupation otherwise filled by fansellers as well as printers and engravers (Clayton 1997, 130). Even in North America, some specialization in map coloring was apparent from the accounts of Philadelphia-based mapmaker Mathew Carey, who employed colorists for his cartographic productions (Bosse 2012, 32). Thus the business of color varied in nature and price from place to place.

The separation between engraving and the application of color could lead to a loss of control by the author of a map; after the map was sold, they could only complain about the results. These complaints reflect the tension between the techniques of *lavis* and *enluminure*. Pierre Duval, nephew of Nicolas Sanson, denounced illuminators "who divide the maps according to the dotted lines that they find on them and who often place the color against the rules of geography, as when they sometimes don't find any dotted lines but paint their brushes along the widest rivers or follow their own caprice and thus distribute large and small regions to sovereigns of state based on their own whim" (Duval 1672, 59). Errors could also come from a bad choice of colors, as specified by Robert Dossie (1758, 329–30): "There is indeed one thing in particular [that] should be always avoided: it is, the laying those colours, that [are similar], close to each other: for by an error in this particular, they will be rendered much less effectual with respect to the purpose they are to serve; . . . more difficult to the eye, to distinguish the limits and bounds they are intended to mark out: and indeed, besides, for want of due apposition, the diversification of the colours is made less pleasing, when they are seen at a distance, and considered only with respect to their ornamental appearance."

Such difficulty was not just hypothetical; two years earlier a discussion was published on the errors of John Mitchell's *A Map of the British and French Dominions in North America* (1755): "We observe that you have drawn a line from *Rockland* in latitude 40 deg. on *Hudson's* river to the mouth of the *Lecba* branch of *Delaware* river in the latitude of 40 d. 37 m. and call it *Limits claimed by New York*. This line is put upon an equal footing with the line called in your map, *Limits claimed by New Jersey*. Nay, if regard be had to the colouring of your map, greater credit is given to the line to the *Lecba* than to the latter line" (Johnston 1756, 287).

The numerous manuals of the period attempted to limit these difficulties as well as respond to the demand of "persons of quality." However, for a more detailed account of the preparation and costs of color, a deeper appreciation of how color could create meaning on a map, one turns to the instruction manuals written for the large-scale mapmakers.

Parallel with the growth of manuals and instructions for map coloring in the printed commercial market was the publication of written directions for large-scale mapmaking, for both private audiences (property mapping, architectural drawing, civil engineering) and specialized public audiences (military and administrative mapping), in terms of coloring maps that often remained in manuscript. These manuals may be divided into two types: those that emphasize technique as much as the choice of colors and those that attempt to standardize the use of color in order to simplify and clarify map use. An example of those concentrating on the technical aspects of coloring may be found in the work of Thomas Breaks, with instructions for manuscript large-scale estate plans: "Having the Plan of a Gentleman's Estate, &c. to wash, first begin with one of the Fields, and dipping your Pencil in the Colour you design to use, draw it along on the Inside of the Lines, making the coloured Part of an equal Breadth; you may make it either broader or narrower, according to the Size of the Field; then dip a clean Pencil in fair Water, and draw it along on the Inside of the coloured Part, washing down the Edge that the Colour may fade or die away down to the Paper, and appear strong next the Lines. It is customary with Surveyors to wash each Field with one intire Colour: This is left to the Discretion of the Surveyor" (Breaks 1771, 446).

The second type of manual generally concerned manuscript maps and plans and offered instruction for the coloring of three types: the *plans-terriers* (cadastral or property maps), military maps, and large-scale maps prepared for engineering projects. The rule here was: "When time allows one to make an accurate drawing, one should use colors to render the objects [of the map] more distinct" (Brühl 1770, 9). The manuals also often provided instructions for fabricating colors. The manuals written for military personnel multiplied the methods of color fabrication while taking into account the conditions of the terrain (Lowengard 2007). Most importantly, these manuals aimed to codify the use of color.

In both the printed and manuscript instruction manuals aimed at military engineers, two important principles established certain typologies. One was the principle of imitation of an idealized nature, which cartography helped to delineate. The other was the principle of normalization and codification of color in order to lock its meaning into the map and avoid the dangers of misinterpretation. The process of simplification by looking for the ideal color, which would sacrifice variability to the advantage of standardization, allowed the establishment of a limited spectrum of colors within which each hue signified a particular meaning.

Thus Nicolas Buchotte, *ingénieur ordinaire du roi*, proposed to imitate "natural color as much as possible, both in military and civil architecture, that is, the grassy areas in greenish-brown; water in sky blue; sandy areas in reddish-yellow; framework structures the color of wood; tile roofs, red tinged with yellow; slate, a grey with a slight blue element" (Buchotte 1754, 45). Yet at the same time, a more abstract codification was becoming equally apparent, one which defined certain colors, like red and yellow, with specific roles. In his 1680 *mémoire* concerning the duties of officers designing fortifications, Sébastien Le Prestre, marquis de Vauban, specified that "the engineer will prepare at the end of the year a rather large plan on which all the elements that compose it can be clearly distinguished: on this plan he will make sure to color with red all those projects that have been completed. Elements that remain only projected and for which work has not yet begun, will be colored with yellow, in order to distinguish them from the other, and the elements of the old plan or the old works which will be effaced by the new design, will be simply represented by dotted lines. This is a rule that one must follow exactly in order to avoid confusion that can be caused when the coloring of plans is done indifferently, with all sorts of colors, and one color could be taken to mean something else" (quoted in Sanger 1999, 50).

Buchotte's work, first published in 1721, was followed by that of Louis Charles Dupain de Montesson in 1750, which reinforced the idea that repetition can become a rule: "It is not enough to know how to set down a line on plans and maps to have tried to manage the paintbrush, one must understand the colors and what it is agreed that they signify in terms of the different parts of a fortification, a landscape, etc." (Dupain de Montesson 1750, 95). So again the color vermillion red was used for constructed buildings; "works projected or newly made are colored with *gomme gutte* or another shade of yellow," with each color being distinct enough to tell one color from another (Dupain de Montesson 1750, 104–5). These texts also offered in the form of a dictionary the link between an object to be represented on the map and the color to be associated with it, as in this example:

> *Abbaye* . . . Color the bell tower blue and the roof of the church in red with vermillion . . .
>
> *Arbre de remarque*. Draw it a little larger than the others, observing its actual shape more precisely and give it a little brush of greenish-brown with the brush on the side of the shadow and with clear yellowish green on the side of the light . . .
>
> *Bourg*. Design it in plan and color it with carmine, such as it will be and fill in any buildings with a half-shade, making sure to put a little cross on the church. (Buchotte 1754, 173)

In this same edition Buchotte also supplied the prices of colors and offered advice on where to purchase them (193–96). Dupain de Montesson went further in *Le Spectacle de la Campagne* (1775), offering a work in which all the colors and the natural and man-made forms they represented were displayed, an approach adopted by professors of fortification (fig. 178).

The growing role of these dictionaries and manuals extended beyond the domain of military engineers to the civil engineers of the corps des Ponts et Chaussées in France, marking the route toward standardization. The *contrôleur général* Philibert Orry, who helped establish the corps, reiterated in his "Mémoire instructif sur la réparation des Chemins" of 13 June 1738: "the parts of the roads that are paved should be colored in red, those that are metaled with stones in yellow, those of loose gravel in gray, and the parts of the natural terrain that have been left untouched by roadworks should be left blank, whether these latter sections have been aligned or not. The copy of this map thus colored, with titles, legends, and the usual significations, will be remitted to the *intendants* and sent on by them" (reproduced in Vignon 1862–80, vol. 3, Pièces justificatives, 6).

Property mapping efforts throughout Europe similarly worked toward a codification of color. In northern Europe from the early seventeenth century, the question

(*facing page*)
FIG. 178. PIERRE PANSERON, *ETUDE POUR LE LAVIS*, CA. 1781. Panseron, professor of design and architecture at the École royale militaire in Paris, published this broadsheet, which followed Dupain de Montesson's recommendation of using colors that displayed a realistic representation of all the colors and the natural and man-made forms of the countryside and city. The sheet also explains the mixing of colors to achieve the natural look.
Size of the original: 39.0 × 22.8 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Maps 8-N-1781 Pa).

ETUDE POUR LE LAVIS

ou il est fait mention du mélange & de l'Emploi des Couleurs dans les Plans de Fortifications & les Cartes Topographiques.

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CET OUVRAGE est très utile aux Architectes, Ingénieurs Civiles et Militaires et aux Arpenteurs.

MANIERE d'employer les Couleurs dans les Plans de Fortifications & Cartes Topographiques

L'USAGE ordinaire pour l'emploi des couleurs est d'en faire le mélange au moment de s'en servir; Quand elles sont composées d'avance, l'on remue chaque couleur en particulier pour les bien mélanger.

L'on fait épaissir au Soleil ces différentes Couleurs dont nous allons parler, au dégré convenable pour les mettre en usage.

Après avoir passé au trait ce qui doit être à l'encre de la Chine, l'on indique au trait a l'encre rouge ce qui est muraille et Batimens.

Ensuite l'on dessine les ombres et les adoucissements nécessaires à l'encre de la Chine claire

Après l'on figure les Rochers, les Coteaux et les Montagnes avec de la terre d'Ombre.

Les Rochers se colorent avec une teinte rougeatre faite avec du crai on rouge.

Ensuite l'on pose la teinte de fond pour les Prairies et les Bois, qui se fait avec de la gomme Gutte et du Vert d'eau, le Jeaune domine.

Après cela l'on pique les Prés à la plume avec du Vert à pocher les arbres qui se fait avec du Vert d'eau et de la Gomme Gutte. Le Vert domine, l'on fait épaissir ce mélange de Couleurs au Soleil.

Le Gazon se fait avec le Vert à pocher les arbres, éclairci avec de l'eau.

Les teintes de fond pour les terres labourables et les Vignes, se font avec une teinte de prairie légere et une teinte légere d'encre rouge, l'on pose ces deux teintes alternativement en se fondant l'une avec l'autre aux extrémités ou elles se rencontrent, après que ce fond est bien sec on pointille au pinceau avec de la terre d'Ombre ou du Bistre, ce qui est jachere, et ce qui est Emblavé avec du Vert à pocher les arbres affoiblit.

Tout ce qui est Riviere, Fossé rempli d'eau, Etang et Marre, se représente avec du Vert d'eau pure affoibli avec de l'eau et ondoyé à la plume avec du Vert d'eau plus épais.

Tout ce qui est massif de Bois après que le fond jaunatre est posé et bien sec, l'on pose le Vert à pocher les arbres, quand il est parfaitement sec, on y dessine les arbres à la plume avec de l'encre de la Chine bien épaisse, après on les ombre au Pinceau avec de l'encre de la Chine moins forte. (a)

Les Terres en friches se font avec du Vert à pocher les arbres, mêlé avec de la terre d'Ombre ou du Bistre mis au dégré convenable avec de l'eau.

L'on fait les Echalats des Vignes avec du Bistre à la plume et les Seps avec du Vert à pocher les arbres à la Plume.

Les Sablieres se représentent avec une teinte légere de Bistre et pointillé à la plume avec du Bistre plus foncé.

Les Massifs de Villes, Chateaux, et Maisons se remplissent avec de l'encre rouge claire et du côté de l'ombre avec la dite encre plus foncée.

Les Ponts de Bois se dessinent avec du Bistre ainsi que les Moulins à vent, croix de Bois et Glaciere.

(a) Quand on est assuré que l'encre de la Chine ne se detent pas l'on peu dessiner les arbres en premier lieu ensuite les ombrer et les pochers comme il vient d'être dit.

of color was considered important enough that in 1636, surveyors were given instructions for standardizing colors: "Cultivated fields were to be colored gray, meadows green, mosses yellow, fences black, lakes light blue, rivers dark blue, boundaries red, forests dark green, and stony slopes white" (Kain and Baigent 1992, 52). In Great Britain, where property surveyors were producing plans from the end of the sixteenth century, the same sort of codification was being set in place, as demonstrated by *Albert Durer Revived* (1697, 11): "Red-lead is the nearest to an Orange Colour, and putting a little Yellow Berries into some of it, it will make a perfect Orange Colour, but if you mean to make Flesh-Colour of it you must put no Yellow, but only then when you would make an Orange Colour. This Colour is used for the Colouring of Buildings, or High-ways in Landskips, being mixed with a little White."

By the eighteenth century, the standardization of color became normal practice in the creation of large-scale manuscript maps made for specific purposes. Codified color increased legibility and understanding for the map reader and thus facilitated decision making and planning. Color, in its tangible forms of pigments, water, and brush, was a technical tool for the mapmaker along with paper, pencil, pen, and ink, and brush and water for gray washes. Each tool was employed to create meaning for every element of the map.

By contrast, the printed map, which was dominated by maps created at medium to small scale and designed to meet the needs of a much more general audience, did not employ color as part of the mapmaking process, but rather as an additional enhancement of meaning already signified by the use of font, line (dotted, solid, stippled), and symbol—all of which were engraved on the copperplate with burin or needle, inked with black, and printed on white paper. Color served essentially to highlight printed meaning until the last quarter of the eighteenth century, when thematic mapping made greater demands on the palette. Attempts to print in color appeared in the early sixteenth century and continued into the seventeenth and eighteenth centuries, but the requirements of careful registration of blocks or plates and a fine understanding of printing pigments meant that printed color was always less common than printing with black ink.

The eighteenth century closed with two paradoxical developments relating to color and printed maps: an increasing use of color on thematic maps and an absence of color on printed military maps. Only during the latter part of the eighteenth century, when various forms of thematic mapping became more common with the growing interest in the distribution of natural and man-made phenomena in space, was color employed in a way to signify something beyond what was already printed. This use of color was also helped by early experimentation in color printing. In general, thematic maps printed in the last quarter of the century continued to add color to the black and white outline of the map, often according to printed keys or legends. Around 1778, Marie Le Masson Le Golft used color to imitate nature by coloring different regions of the world according to the skin color of the inhabitants. Leaving areas white on the map did not indicate a lack of information, as on earlier maps, but reflected the color of the skin of European inhabitants, thus giving white a "natural" meaning (see fig. 234).

Similar maps employing added color to emphasize spatial distribution of phenomena may be found in other European map publications, as in Italy for the distribution of doctors around Pavia (*Topographia agroiatrica mediolanensi,* 1782, Giuseppe Cicognini), and in Austria for the distribution of ethnic groups and language (1791, Johann Matthias Korabinsky, *Novissima Regni Hungariae potamographica et telluris productorum tabula*). Color could dramatize political themes and

FIG. 179. DETAIL FROM THE SOCIETY OF ANTI-GALLICANS, *A NEW AND ACCURATE MAP OF THE ENGLISH EMPIRE IN NORTH AMERICA* (LONDON: WILLIAM HERBERT & ROBERT SAYER, DECEMBER, 1755). Scale, 1:7,000,000; scales of insets vary. This detail from the map of the British claims in North America shows the "encroachments of the French," i.e., with white to contrast with the pink/rose background of British claims in this cartographic prelude to the Seven Years' War.
Size of the entire original: 43.5 × 81.3 cm; size of detail: ca. 14.5 × 14.0 cm. Image courtesy of the William L. Clements Library, University of Michigan, Ann Arbor (Maps 2-K-1755 So).

nationalist aspirations, as with the 1755 multicolored map of the English empire in North America, which displayed the French forts as white pockmarks on the vividly hued English claims (fig. 179). Growing interest in geology and the spatial distribution of rock formations also focused attention on color and its deployment as a meaningful cartographic symbol. Initially, the principle of imitation of nature was used in the earliest of geological maps, produced primarily in the German states, on which colors signified types of rock by imitating the shade of the rock itself. Professor Abraham Gottlob Werner of the Bergakademie Freiberg produced an unpublished "Farben Tafel" (table of colors) for his students to use based on imitation; it contrasted with the more theoretical proposal of Johann Wolfgang von Goethe, whose amateur enthusiasm for geology led him to develop a theory of color (*Farbenlehre*) that was not based on the rocks' appearance but on their origins and the harmonic arrangement of colors, thus pointing toward a stratigraphic color scheme based on age. Goethe's theoretical work strongly influenced the coloring on Christian Keferstein's *General Charte von Teutschland* (1821) (Schäfer-Weiss and Versemann 2005). In contrast to both the use of thematic color added to printed maps and to the long tradition of color on manuscript military maps, especially in France, color did not play a role on the large-scale printed military maps known as the carte de l'État-Major. The Commission de topographie of 1802 oversaw the production of this new map of France and ruled out color as an element on it. The debates concerning this question were published and the argument is clear: "They say that colors make clear what lines leave in doubt. Is color necessary? The line alone is insufficient; it deceives [the eye]: missing color allows the error to stand. The horizontal line, by contrast, done in full [solid] or dotted never deceives the eye: it is sufficient for rendering escarpments, for the overhangs of routes through hollows, for ravines" ("Topographie" 1803, 29).

The relationship of color to cartography permeated different aspects of map production throughout the period of the Enlightenment from the most material aspects of the map (paper, manuscript tools, engraving procedures, costs, workshops, and artisans) to the consideration of colors themselves, what they represent and their standardization to the construction of the meaning of white or blank space as nothing (a lack of information) or something (significant information for which no color is required).

In the *Encyclopédie,* Jean Le Rond d'Alembert hierarchized two aspects of what he called the *corps*: shape, which offers "the most general and the most abstract point of view that we can envisage," and color, which, when associated with shape, allows one to distinguish bodies from the depths of space. In fact, he considered shape to be necessary for this distinction, since it was "easier to consider shape in a mass without color than to consider color without shape, whether finally because shape allows different parts of space to be fixed more easily and in a less vague way" (d'Alembert 1751, 1:v). Color therefore would only be an accessory in the perception of shapes. This view is found in most of the manuals of cartography from the seventeenth and eighteenth centuries, which put the addition of color in second place, after the question of shapes and outlines has been settled. Moreover, these reflections concerned the variability of color, whether due to questions of physics or optics, since the question of color was most often linked to the portrayal of landscape and, beyond this, to topographical views (Verdier 2010). However, Denis Diderot went further, in the manner of Étienne Bonnot de Condillac, by making color the primary element, asserting that drawing gives form to beings, but color "gives them life" (Diderot 1795, 15). In this way, the *Encyclopédie* approached the definition given for the word *coloris:* "color is what renders objects visible" (Landois 1753). This dichotomy, while constructed within the context of painting, found its full force in the cartographic production of the Enlightenment; caught between the necessities of shape and the power of colors.

NICOLAS VERDIER AND JEAN-MARC BESSE

SEE ALSO: Art and Design of Maps; Reproduction of Maps: Color Printing; Signs, Cartographic; Thematic Mapping

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Color Printing. See Reproduction of Maps: Color Printing

Commission topographique of 1802. Convened from 15 September to 15 November 1802 in order to "simplify and standardize the signs and conventions in use on maps, plans, and topographic drawings," the Commission topographique was composed of twenty-one specialists from various bodies: fifteen military representatives (Dépôt de la Guerre, Corps du Génie, and *ingénieurs géographes*), two from the Ponts et Chaussées, two from the Corps des Mines, one from the Service de la Marine, and one from the Administration des forêts ("Topographie" 1803, 1–3). During the French Revolutionary Wars, an enormous amount of cartographic material from topographical offices and conquered countries flooded the Dépôt de la Guerre, established in Paris in 1791. First Consul Napoleon Bonaparte wanted to have the maps printed immediately and distributed to military staff headquarters. From the Directoire, he supported large cartographic undertakings (Egypt 1798, Swabia 1800, *départements réunis* 1801). Aided by his chief of staff, Louis-Alexandre Berthier (named minister of war in 1799), Napoleon formed an office for cartography directed by Louis Albert Guislain Bacler d'Albe. The geodetic network established by Jean-Baptiste-Joseph Delambre and Pierre-François-André Méchain provided a consistent metric grid and made the future emperor aware of the need for a universal system of cartographic conventions.

To that end, the commission adopted (1) the metric system and the decimal scale, (2) a north orientation, (3) the level of the lowest seas as the base for surveying, (4) a system of codified hachures and the horizontal projection, and (5) conventional signs and standardized lettering adapted to the scale and to the needs of users. Combining different representations on a single map (plan, profile, perspective) was forbidden. The only exception was on navigational charts, which retained their helpful coastal profiles.

The debates within the Commission demonstrated the difficulty of reconciling specialists' habits with the universal expectations of the Commission. The representation of relief prompted long discussion: could a map be both immediately readable (graphically evocative) and precise (i.e., measurements could be made based on it)? Contour lines won unanimous support, but they were abandoned because of the rigorous level of surveying required. Finally, after weighing the drawbacks of using color, the Commission opted for a system of lines whose thickness varied according to "the steepest slope" (the imaginary path of water down a slope) ("Topographie" 1803, 37). At smaller scales, these hachures, underlined by shading (with the light coming from the northwest), would become a conventional sign, varying by type of slope ("Topographie" 1803, 42). Spot heights would signify the various altitudes of landscape features that would be colored to imitate nature ("Topographie" 1803, 44). The Commission produced a vast array of conventional signs for chorography, hydrography, mineralogy, and military and naval requirements. With set rules for mixing colors, the commission prescribed a rigorous color code for manuscript draft maps based on classifications of a map's features. It provided a graph with heights of letters according to a hierarchy of nomenclature and to the scale of the map ("Topographie" 1803, 51–55, pls. 1, 2, 14). Despite its simplified calculations and scale transposition, the newly created metric system was very poorly received.

As a true product of political willingness to embody the principles of the French Revolution (universalism and progress), the Commission topographique of 1802 created a new science: topography. In Pluviôse, year XI (January 1803), the Commission chose the Bonne projection. In 1803, Bacler d'Albe completed the Commission's work with a tutorial on map engraving. The report of the Commission was published with Bacler d'Albe's tutorial in 1803 and critically republished in 1831, laying the groundwork for the carte de l'État-Major.

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SEE ALSO: Heights and Depths, Mapping of: Relief Depiction; Military Cartography: France; Topographical Survey Map; Topographical Surveying: France

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Compagnie des Indes (Company of the Indies; France). The history of the Compagnie des Indes may be traced to two earlier seventeenth-century companies formed as a French response to European exploitation of the Americas and the Far East. France had never recognized the Treaty of Tordesillas (1494) that divided the New World between Spain and Portugal, and sixteenth-century French merchants, following the English and Dutch, engaged in commerce on the coasts of Canada and Florida, as well as on a number of Caribbean islands.

In 1627 the minister Armand Jean du Plessis, Cardinal Richelieu, created the Compagnie de Cent Associés to invest in the development and population of the Canadian colony. This company, organized on the English and Dutch models but with the state as the principal investor, enjoyed a royal concession for commercial monopoly and landownership in exchange for its commitment to populate and administer the colony. In the Antilles, the Compagnie de Saint-Christophe (1626) became the Compagnie des Isles d'Amérique (1635) after the colonization of Guadeloupe and Martinique.

These first French companies proved to be, on the whole, ineffective as instruments for an economic organization of the colonies that permitted a division of roles between the king (army, justice) and any organisms of commercial and demographic administration. The companies were not able to produce sufficient investment in territories where they found fierce competition with the Dutch and English, nor could they motivate sufficient emigration to the colonies. Thus, they were content to trade with rival powers, an activity that accounted for the bulk of their maritime traffic. Company directors sought rapid profits, while the ship owners in French ports involved in Atlantic commerce (Bordeaux, Nantes, Saint-Malo, Le Havre) strongly disapproved of any form of monopoly or price control. The state, which held the majority of shares in the companies, soon took direct control of the colonies, allowing commerce to organize itself freely. Finally, by the seventeenth and eighteenth centuries, commercial companies of merchants and ship owners linked to an Atlantic or Channel port largely replaced these earlier companies in French colonial traffic.

In 1664 Jean-Baptiste Colbert encouraged Louis XIV to replace the Cent Associés with a new commercial company capable of competing with the Dutch and the English. The Compagnie des Indes was divided into geographic sectors: the Indes orientales (Madagascar, the Indies, China, and the East) and the Indes occidentales (the Americas and the concession for the trade in African slaves). The capital required for the company included investments by the king and royal family with 45 percent (15 million livres); the nobility and ministers of court, 19.5 percent; merchants, 16 percent; and private financiers, who were strongly encouraged by the administration, 8.5 percent (Haudrère 1989, 1:26). The initiative was supported by the king's considerable efforts to create a powerful navy that would allow France to establish and defend autonomous commerce with its colonies. In 1666 the Compagnie des Indes created its own port in Brittany, symbolically christened "L'Orient" (Lorient), and it supported efforts to populate the colo-

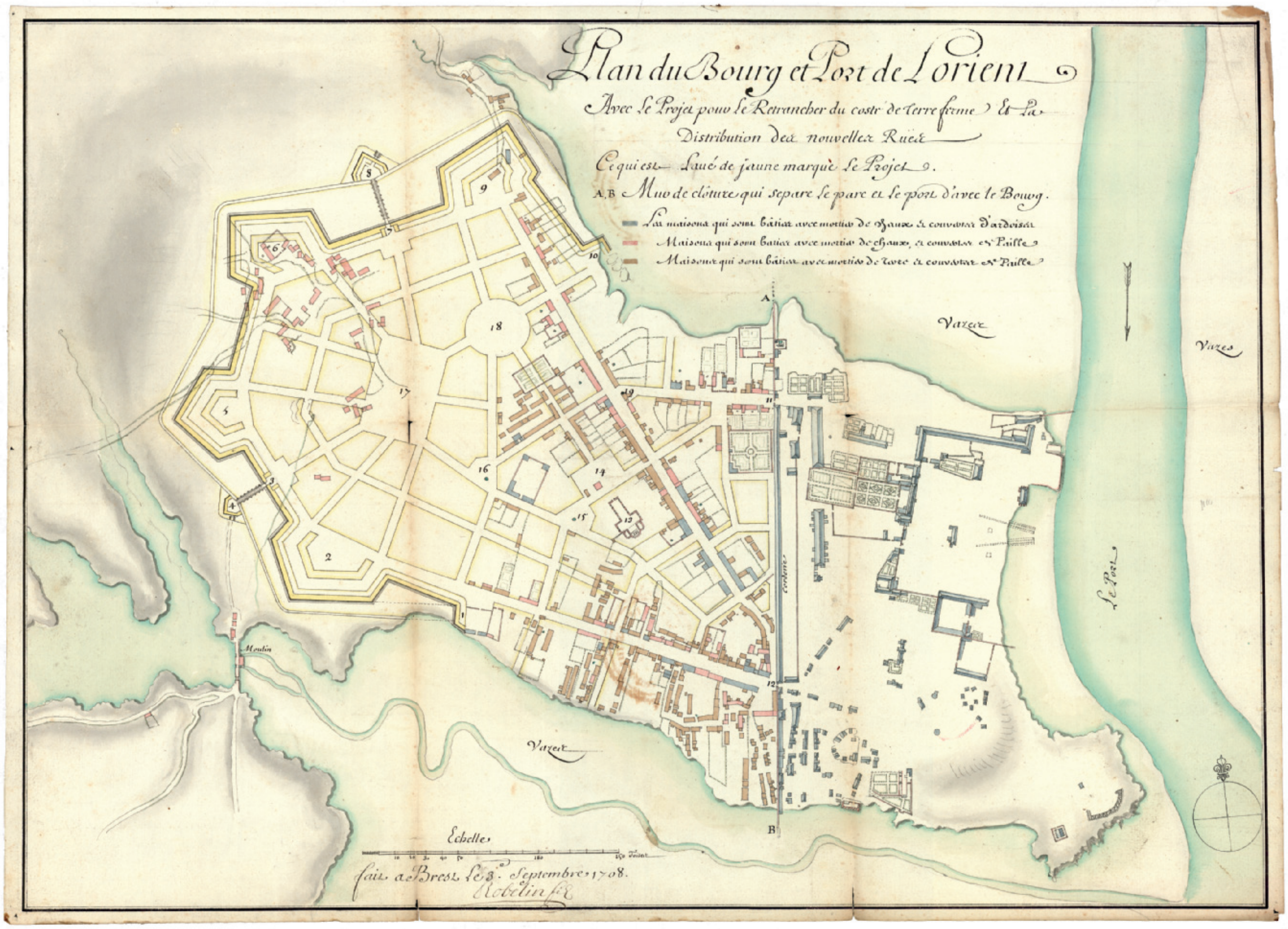

FIG. 180. ISAAC ROBELIN, "PLAN DU BOURG ET PORT DE LORIENT," 1708. Manuscript map designed by the chief engineer of Brest. Son of an engineer, Robelin was named engineer in Rennes after the great fire of 1720. Louis Pierre Le Blond de la Tour, the chief engineer of colonial Louisiana, was his nephew. The plan uses the military color scheme of yellow for proposed new streets and three other colors for the buildings, depending on the materials used.
Size of the original: 36.0 × 50.1 cm. © Service historique de la Défense, Vincennes (1 V H 982, pièce 14).

nies, even if the king made the inadvisable decision to deny the Huguenots a colonial refuge (fig. 180). In Lorient were deposited the muster rolls, registries of trade, logbooks of the vessels, and maps, frequently Portuguese or Dutch, the vagueness of which was a source of numerous complaints from the navigators who used them.

The Compagnie des Indes occidentales, established in 1664 with the absorption of two other companies (serving the slave trade from Guinea and Senegal), lasted only ten years. It was ill-supported by the colonists, who lost their freedom of commerce because of it, and the Franco-English wars ruined its fleet of forty-five vessels. At its demise in 1674 the Crown once again assumed administration of the colonies in America.

One year after the Treaty of Ryswick (1697), the Compagnie de Saint-Domingue was founded, but beginning in 1701 the War of the Spanish Succession interrupted commerce. In 1712 the banker Antoine Crozat created a new company for commerce named Compagnie de la Louisiane, but the ruinous enterprise was abandoned five years later. In 1717 John Law created the Compagnie d'occident for the development of Louisiana.

After the bankruptcy of Law's enterprise, the Compagnie perpetuelle des Indes was formed in 1719, combining all the French commercial companies of both east and west. This structure would survive the bankruptcy of its bank in 1720, but from 1731 it abandoned the unprofitable Louisiana to the control of the king. During the period of its greatest prosperity (1750–55), the Compagnie des Indes had sales totaling about twenty million livres, equal to those of its English rival and scarcely inferior to that of the Verenigde Oost-Indische Compagnie (VOC) and the West-Indische Compagnie (WIC). During this same period, the activity of the company generated a significant renewal of cartography. The company's hydrographer, Jean-Baptiste-Nicolas-Denis d'Après de Mannevillette, concentrated on general and detailed charts of the coasts and water routes from West Africa to the East Indies, where he had traveled; none were devoted to North America or the Caribbean, which he did not know. The company contributed funding to the first publication of his famous *Le Neptune oriental* in 1745 but never sought to produce equivalent maps or charts for the western routes and colonies, although several naval officers who served in the Compagnie as well as other marine officers contributed important observations and navigational information on sea routes to company outposts in the Indian Ocean and East Indies. As the number of documents and need for order grew, an official archive, the Dépôt des cartes et plans de la Compagnie des Indes, was finally created in 1762 with d'Après de Mannevillette as director, who continued to amass information from navigators and the unofficial depots of the company on the Île-de-France (Filliozat 2003).

Ruined in part by the Seven Years' War (1756–63) and the consequent loss of its colonies by the terms of the Treaty of Paris (1763), the Compagnie des Indes went bankrupt in 1770. A symbol of its power, the arsenal of Lorient, a city of 15,000 inhabitants, was yielded back to the king. The company reappeared only very briefly under Louis XVI (1785) before disappearing definitively during the Revolution (1792) (Haudrère 1989, 4:1146). The contents of its map collections were transferred in 1780 to the Dépôt des cartes et plans de la Marine and are housed in the Archives nationales de France, Paris.

GILLES-ANTOINE LANGLOIS

SEE ALSO: French East Indies; Marine Charting: France; *Neptune oriental, Le*

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Compass, Marine. See Instruments for Angle Measuring: Marine Compass

Compass, Surveyor's. See Instruments for Angle Measuring: Circumferentor

Composite Atlas. See Atlas: Composite Atlas

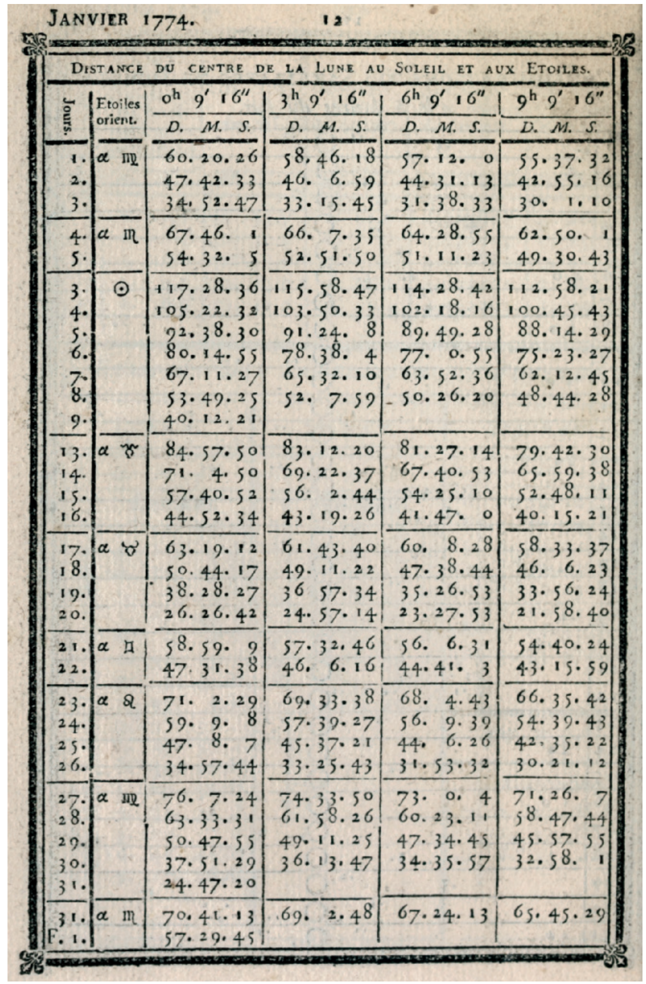
Connoissance des temps. Although astronomical almanacs had been privately published in France and Europe since the Middle Ages, Louis XIV and his minister Jean-Baptiste Colbert left their mark in the domain of astronomy by establishing the Paris Observatory, begun in 1667 with the main construction completed by 1672 (the interior was finished about ten years later). Yet it was private initiative that prompted the appearance of the first edition of *Connoissance des temps* in 1679, generally attributed to the astronomer Joachim d'Alencé, who supervised publication through the 1684 edition (Boistel 2001, 1:178), before he became a secret agent. Jean Le Fèvre took over publication in 1685. From 1690, the *Connoissance des temps* included tables predicting the immersion and emersion of satellites of Jupiter, which Jean-Dominique Cassini (I) had published in his *Ephemerides Bononienses mediceorvm sydervm* from 1668. These data were used to calculate longitude by comparing the predicted time for an astronomical event at the meridian of origin (printed in advance for this reference meridian) with the local time of the phenomenon's observation. This procedure allowed the observer to determine the hour (and, therefore, the angle) of longitude at the place of observation. Jean Picard and Philippe de La Hire, astronomers at the Académie des sciences, made wide use of this method for their map of France, presented to the Académie in February 1684 and published in 1693 (see fig. 625); longitude information also benefited *Le Neptune françois* (Chapuis 1999, 102).

Following a conflict between La Hire and Le Fèvre, the Académie des sciences received the privilege to publish the *Connoissance des temps* in January 1701 (Boistel 2001, 1:180–87). A series of astronomers, members of the Académie, directed successive redactions and editions: Jacques Lieutaud from 1702 to 1729, Louis Godin from 1730 to 1734, Giovanni Domenico Maraldi from 1735 to 1758, Joseph-Jérôme Lefrançais de Lalande from 1759 to 1775 (under the title *Connoissance des mouvemens célestes,* 1762–67), Edme-Sébastien Jeaurat from 1776 to 1787, and Pierre-François-André Méchain until 1794. Publication privilege passed to the Bureau des longitudes (established 25 June 1795) with the edition of September 1795 (with spelling modernized to *Connaissance des temps*).

Although he did not hold the longest tenure as director of the *Connoissance des temps,* Lalande's leadership marked a decisive stage in its history. Encouraged by the Académie de marine, he began including data allowing the calculation of longitude at sea, transforming the work into a veritable nautical ephemeris. In the 1760 edition, Lalande explained the method of lunar distances, whereby one would measure and correct the true distance from a star to the moon and then look for this same angular value in the tables of the almanac to learn at what time the same observation took place at the meridian of origin. The difference in time between the place of observation and that of the place of origin would correspond to the longitude. In England *The Nautical Almanac* (1766 for 1767) gave, for the first time, the angular distances between the moon and the sun (as well as seven other stars) every three hours at Greenwich.

Conscious of Great Britain's progress in determining lunar distances, the Académie de marine convinced Lalande to integrate English data for lunar distances into the *Connoissance des temps,* starting with the 1772 (for 1774) publication (fig. 181). This edition of the *Connoissance* (appearing six years after *The Nautical Almanac*) gave the distance from the moon's center to the sun's center and to the brightest stars at three-hour intervals for every day of the month (Chapuis 1999, 70). These distances were given relative to the Paris meridian beginning only in the 1786 edition (for 1789), two years after the *ministre de la Marine* sought to increase the work's circulation by asking the Académie de sciences for a new design that would make the work affordable for officers of the merchant marine. His goal was to motivate these officers to use lunar distances, as officers of the Marine (whose elite also possessed clocks) were already doing. While of great potential benefit to all sailors, the challenge lay in convincing them to accept a work conceived originally for astronomers. Tables for lunar distances in the *Connaissance des temps* disappeared only in the 1905 edition (for 1908). Ultimately, although the work did not contain all the points determined astronomically, its publication reveals the evolution of applied astronomical knowledge in the course of the eighteenth century (Chapuis 1999, 26–27).

OLIVIER CHAPUIS


JANVIER 1774. 12

DISTANCE DU CENTRE DE LA LUNE AU SOLEIL ET AUX ETOILES.

Jours.	Etoiles orient.	0h 9′ 16″ D. M. S.	3h 9′ 16″ D. M. S.	6h 9′ 16″ D. M. S.	9h 9′ 16″ D. M. S.
1.	α ♍	60. 20. 26	58. 46. 18	57. 12. 0	55. 37. 32
2.		47. 42. 33	46. 6. 59	44. 31. 13	42. 55. 16
3.		34. 52. 47	33. 15. 45	31. 38. 33	30. 1. 10
4.	α ♏	67. 46. 1	66. 7. 35	64. 28. 55	62. 50. 1
5.		54. 32. 5	52. 51. 50	51. 11. 23	49. 30. 43
3.	☉	117. 28. 36	115. 58. 47	114. 28. 42	112. 58. 21
4.		105. 22. 32	103. 50. 33	102. 18. 16	100. 45. 43
5.		92. 38. 30	91. 24. 8	89. 49. 28	88. 14. 29
6.		80. 14. 55	78. 38. 4	77. 0. 55	75. 23. 27
7.		67. 11. 27	65. 32. 10	63. 52. 36	62. 12. 45
8.		53. 49. 25	52. 7. 59	50. 26. 20	48. 44. 28
9.		40. 12. 21			
13.	α ♈	84. 57. 50	83. 12. 20	81. 27. 14	79. 42. 30
14.		71. 4. 50	69. 22. 37	67. 40. 53	65. 59. 38
15.		57. 40. 52	56. 2. 44	54. 25. 10	52. 48. 11
16.		44. 52. 34	43. 19. 26	41. 47. 0	40. 15. 21
17.	α ♉	63. 19. 12	61. 43. 40	60. 8. 28	58. 33. 37
18.		50. 44. 17	49. 11. 22	47. 38. 44	46. 6. 23
19.		38. 28. 27	36 57. 34	35. 26. 53	33. 56. 24
20.		26. 26. 42	24. 57. 14	23. 27. 53	21. 58. 40
21.	α ♊	58. 59. 9	57. 32. 46	56. 6. 31	54. 40. 24
22.		47. 31. 38	46. 6. 16	44. 41. 3	43. 15. 59
23.	α ♌	71. 2. 29	69. 33. 38	68. 4. 43	66. 35. 42
24.		59. 9. 8	57. 39. 27	56. 9. 39	54. 39. 43
25.		47. 8. 7	45. 37. 21	44. 6. 26	42. 35. 22
26.		34. 57. 44	33. 25. 43	31. 53. 32	30. 21. 12
27.	α ♍	76. 7. 24	74. 33. 50	73. 0. 4	71. 26. 7
28.		63. 33. 31	61. 58. 26	60. 23. 11	58. 47. 44
29.		50. 47. 55	49. 11. 25	47. 34. 45	45. 57. 55
30.		37. 51. 29	36. 13. 47	34. 35. 57	32. 58. 1
31.		24. 47. 20			
31.	α ♏	70. 41. 13	69. 2. 48	67. 24. 13	65. 45. 29
F. 1.		57. 29. 45			

FIG. 181. PAGE FROM THE *CONNOISSANCE DES TEMPS* FOR JANUARY 1774. The result of an intense debate between the Académie de marine, the Académie des sciences, and Lalande, this edition is the first publication of a French almanac containing English data for lunar distances. The reproduction here shows the distance from the center of the moon to the center of the sun and to the brightest stars for each day of the month at three hour intervals. From Joseph-Jérôme Lefrançais de Lalande, ed., *Connoissance des temps, pour l'année commune 1774* (Paris: Imprimerie Royale, 1772), 12.
Size of the original: ca. 17 × 11 cm. Image courtesy of the Bibliothèque nationale de France, Paris.

SEE ALSO: Longitude and Latitude; Marine Chart; Marine Charting; Navigation and Cartography; Paris Observatory (France)

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Constellations, Representation of. Constellations were introduced in antiquity as an aid for marking and memorizing individual stars in the sky. The relative positions of the stars could then be presented in terms of the head, shoulders, arms, or legs of the constellation. During the Enlightenment, constellations progressively declined as a useful cartographic concept. The application of the telescope and the proliferation of observatories in conjunction with Europe's global endeavors dramatically expanded the number of stars cataloged. Thus, whereas Johannes Hevelius in 1690 cataloged 1,888 stars visible with the naked eye, in 1801 the German astronomer Johann Elert Bode listed 17,240 mostly telescopic stars in his star atlas *Uranographia* (Warner 1979, 39). For such an abundance of stars it no longer made sense to specify the position of individual stars within constellation figures, since too many stars would now fit the same description.

The shifting status of constellations can be seen in the increasing violation of the rule formulated by Hipparchus in ca. 128 B.C. (Toomer 1984, 15), stipulating that when the apparent sphere of the fixed stars is mapped on a concave surface, with the stars as they are seen in the sky, constellations are properly depicted facing the reader. Conversely, when the stars are mapped on a convex surface, showing the stars as they are seen on a globe, constellations are properly depicted from the rear, facing into the sphere, with their backs to the reader. In this way, agreement could be maintained between the maps and star catalogs; a star in, say, the left hand of a constellation remains in the left hand. The first Renaissance mapmaker to ignore this rule was Johannes Bayer. The maps in his star atlas *Uranometria* (1603) were constructed as if seen in the sky, yet many of the constellations are shown from the rear; his motive remains unclear (Dekker 2004, 55–57; Friedman Herlihy 2007, 115–17). The first Western globemaker to ignore the rule was Vincenzo Coronelli, who used forward-facing constellations on the grand celestial globe he made for Louis XIV (fig. 182) (Dekker 2012, 144–48). He continued this practice for the printed gores for his convex celestial globes; moreover, he perpetuated the incongruity when preparing gores for the concave inner surface of open spheres by simply mirroring the constellation figures, together with the star configurations, so as to keep them face-forward (Dekker 2004, 61–62). Didier Robert de Vaugondy followed Coronelli's example on his celestial hemisphere of 1764, with the result that the star labeled "le Jambe gauche" is placed on the *right* leg (Warner 1979, 210). A somewhat different example is the celestial sphere on the concave side of the Gottorp globe (see fig. 163): the artist simply drew the constellations as the mirror image of the correctly oriented constellations on a globe, creating a concave presentation with human figures seen from behind (Lühning 1997, 80–81). Similar mirrored images are seen on the concave sides of the cases of many pocket globes. Such developments did not go unnoticed by astronomers: in particular, Flamsteed strongly criticized Bayer for having placed the stars in his *Uranometria* contrary to the Ptolemaic description (Warner 1979, 81–82).

The decline in the functional utility of constellations did not prevent the introduction of new constellations during the Enlightenment (Warner 1979; Dekker 1992). The first extensive additions to the classical Ptolemaic constellations date from the turn of the sixteenth century, especially in southern skies (Friedman Herlihy 2007, 102–4, 117–18). Some attempts to replace the classical constellations were undertaken in the seventeen century. The German globemaker Erhard Weigel designed heraldic globes in which both conventional and his own new constellations were depicted using heraldic imagery. But such innovations did not last: the classi-

FIG. 182. HERCULES ON THE GRAND CELESTIAL GLOBE BY VINCENZO CORONELLI, 1681–83.
Diameter of the original: 390 cm. Image courtesy of the Bibliothèque nationale de France, Paris (Cartes et plans, Ge A 499 RÉS).

cal constellations were too deeply rooted in European culture. Thereafter, astronomers were generally content to add new non-Ptolemaic constellations for newly recorded stars, although not all inventions were accepted by the astronomical communities.

The newly invented constellations can be divided into several groups (Warner 1979, xi–xiii; also the chronological survey in Dekker et al. 1999, 559–60). In the late seventeenth and the eighteenth centuries, the leaders of European states induced a number of political constellations. The English physician Sir Charles Scarborough proposed Cor Caroli Regis Martyris in 1673 in honor of the beheaded English monarch Charles I, and the astronomer Edmond Halley introduced Robur Carolinum in 1678 for the royal oak tree at Boscobel that saved Charles II from the Republicans. The French astronomer Ignace-Gaston Pardies paid tribute to Louis XIV by replacing the constellation Vespa (introduced by Jacob Bartsch, who in turn had replaced an earlier constellation Apes introduced by Petrus Plancius around 1600) by Lilium (1674), and the French architect Augustin Royer added Sceptrum et Manus Justitiae (1679) in the zenith of Paris. The Polish astronomer Johannes Hevelius introduced Scutum Sobiescianum (1684) to commemorate Jan III Sobieski, whereas the German astronomer Gottfried Kirch introduced Gladii Electorales Saxonici (the swords of the electors of Saxony, 1684), Ponum Imperiale (the orb of the German emperor Leopold, 1688), and Sceptrum Brandenburgicum (the scepter of Friedrich Wilhelm elector of Brandenburg, 1688). In the eighteenth century Corbinianus Thomas, a professor of mathematics at Salzburg, renamed the classical Corona Borealis as Corona Firmiana vulgo septentrionalis (1730) to pay homage to the archbishop of Salzburg; the astronomer Marcin Poczobutt-Odlanicki honored Stanisław August Poniatowski of Poland with Taurus Poniatovii (1775); the Mannheim astronomer Karl-Joseph König added the initials of the Elector Palatine Carolus Theodorus and his wife Elisabeth Augusta (C, T, E, A), as well as an imperial lion Leo Palatinus (1785); the German astronomer Johann Elert Bode converted the French Sceptrum into Honores Friderici for Friedrich II of Prussia (1787); whereas with Psalterium Georgianum (1789), Maximilian Hell, director of the Vienna observatory, saluted George III, the patron of the English astronomer of Hanoverian background William Herschel. Charles Messier was the only commoner to be honored with a constellation; French astronomer Joseph-Jérôme Lefrançais de Lalande named Custos Messianum after him in 1775 in appreciation for his contributions to astronomy.

A second major group of new constellations were of various animals. Hevelius introduced ten animal constellations in his star atlas, *Firmamentum Sobiescianum, sive Uranographia* (1690), including Lynx as a reminder that one has to have eyes as sharp as a lynx's to be a good observer. (Hevelius was the last of the astronomers who did not use a telescope to measure the stellar positions.) John Hill introduced another set of thirteen new constellations in his *Urania* (1754); his inventions are small singular creatures that were not noticed by others. Two more animals were mapped by Pierre-Charles Le Monnier: the reindeer (Rangifer, 1743) to commemorate the French expedition to measure the length of a degree in Lapland, and for no clear reason a tropical bird (Turdus Solitarius, 1776).

A considerable extension of the number of constellations came about from the work of the French astronomer abbé Nicolas-Louis de La Caille. In 1751–52 he cataloged 9,800 southern stars, mostly invisible to the naked eye, from his observatory at the Cape of Good Hope. La Caille presented a large manuscript map to the Académie de sciences in 1754, showing the 1,930 brightest ones grouped in fourteen newly invented constellations dedicated to the triumph of science by showing new tools like the pendulum clock (Horologium) (fig. 183). In his star catalog La Caille also subdivided the constellation Argo into four separate constellations, the keel (Carina), the stern (Puppis), the sail (Vela), and the mast (Malus). The first three of them were depicted in a map of Robert de Vaugondy (1764) and would later replace the Ptolemaic constellation Argo. More scientific instruments were added to the sky at the turn of the eighteenth century by Lalande (Quadrans Muralis and Globus Aerostatica), Bode (Officina Typographica, Lochium Funis, and the Machina Electrica), Hell (Tubus Herschelii Major and Minor), and Thomas Young (Battery of Volta).

By 1800 the number of constellations had risen in this rather haphazard way from the forty-eight Ptolemaic constellations to about 108. However, the needs of celestial cartography could not be met by drawing more and more constellations. On his maps, Robert de Vaugondy surrounded each constellation by lines that are "apparently the first instance of these now common boundary lines" (Warner 1979, 210). Robert de Vaugondy's example was followed by Bode in his influential maps and atlases (after 1768) and became an accepted element of celestial cartography. Among the globe firms who responded to the decreasing importance of constellations was that of the Cary family. Early in the nineteenth century, this firm offered two versions of their celestial globes for sale: one conventional globe with fully drawn constellations and another with only the outlines of the area covered by each constellation (Dekker and Van der Krogt 1993, 122–23 [pls. 37 and 38]). The International Astronomical Union completed the processes of rationalization in 1930, when it defined eighty-eight regu-

FIG. 183. DETAIL OF L'HORLOGE (HOROLOGIUM) AND OTHER NEW CONSTELLATIONS IN LA CAILLE'S MAP OF THE SOUTHERN SKY. From Nicolas-Louis de La Caille, "Table des ascensions droites et des déclinaisons apparentes," *Memoires de l'Académie Royale des Sciences, année 1752* (1756): 539–92, pl. 20.
Size of the entire original: 20.3 × 20.3 cm; size of detail: ca. 13.0 × 8.5 cm. Image courtesy of the Department of Special Collections, Memorial Library, University of Wisconsin–Madison.

lar portions of the sky, each associated with the name of a constellation it had once enclosed (Dekker 2002, 76–79).

ELLY DEKKER

SEE ALSO: Celestial Mapping; Globe: Celestial Globe; Hevelius, Johannes; La Caille, Nicolas-Louis de

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Consumption of Maps. This term speaks to the widespread and differing use made of maps by a rapidly growing literate and wealthy public. The rise in the use of maps in the eighteenth century in turn contributed to and reflected increases in map production, expansion in the map trade, and global changes in print culture. For Mary Sponberg Pedley, "The world of printed maps in the eighteenth century included everything from maps used as illustrations in books and periodicals to large-scale estate and town plans, military maps, regional maps, small-scale geographical maps, wall maps, atlases, and globes. All were available in printed form during a period that saw a dramatic increase in the quantity and quality of consumer goods and an equally dramatic increase in the spending power not only of the wealthy, but also of the middling and even working classes" (Pedley 2005, 1).

Map consumption was thus part of much wider and more diverse cultures of consumption. Contemporaries experienced these developments as the consequence of financial wealth gained through trade and manufacturing and realized their greater spending power in many different forms of material possession: fine art, buildings, houses, fashion, and landscape gardens as well as maps. Some commentators were critical of the rise in luxury, seeing in its ostentatious display not new status symbols but enduring social vices and invitations to moral corruption. For modern historians, the consumption of goods, both necessary items and luxury objects, was so marked during the eighteenth century, especially in the later decades, that they have spoken of a "consumer revolution," a "necessary analogue to the industrial revolution, the necessary convulsion on the demand side of the equation to match the convulsion on the supply side" (McKendrick 1982, 9). To understand consumption is to see it as a social, cultural, and geographical phenomenon within an emergent public world as well as an economic issue: “The history of consumption must include analysis of demand, and therefore of the structuring of needs, the classification of consumers, the circuits of distribution and the spatial organisation of supply” (Roche 2000, 14).

The fact that map consumption was part of the wider consumption of print culture, and that consumption in general was closely connected with production—“Consumption is the sole end and purpose of all production” as Adam Smith put it in his 1776 *An Inquiry into the Nature and Causes of the Wealth of Nations* (quoted in McKendrick 1982, 15)—makes it important to see map use in terms of social, economic, cultural, and technical relationships rather than in isolation. One heuristic helpful in this respect is Robert Darnton’s diagram of a communications circuit (fig. 184). This was proposed as part of the then-emerging field of book history to help understand the ways in which printed books pass from the author to the publisher (if the bookseller does not assume that role) to the printer, the shipper, the bookseller, and the reader. With the reader, the circuit is complete since, argued Darnton, it is the reader who influences the author both before and after the act of composition. Later work on the nature of the book in general (Johns 1998) and on the history of reading in particular (Darnton 1991) has further complicated terms such as “reader,” “author,” and “audience.” Yet in its attention to social and technical connections in print culture, Darnton’s 1982 book history model has much to offer students of map history, especially with respect to the connections between consumption and production and for map consumption as a social process.

The trade in maps reflected an increase in production geared toward new levels of consumption. In London and in Paris, the growth in the map trade was apparent from the late seventeenth century. There were six map- and chartselling establishments in London by 1660, and about sixteen by 1690. In both cities, the changing location of mapsellers resulted from a general increase in consumers’ purchasing power, new opportunities consequent upon the national and civic wealth then flowing in and through what were Europe’s two leading scientific cities, and particular local influences upon the market for maps. In London in the 1680s, several mapsellers set up stalls in Westminster Hall to sell to the crowds associated with the Parliamentary sessions, and there was a notable east-west movement within London’s map trade between 1660 and 1720 in order to be near customers: “As the suburbs moved westwards the map-sellers, after a suitable time-lag, followed” (Tyacke 1978, xxiv). In Paris, mapmakers concentrated around the quai de l’Horloge on the Île de la Cité in the city center, with

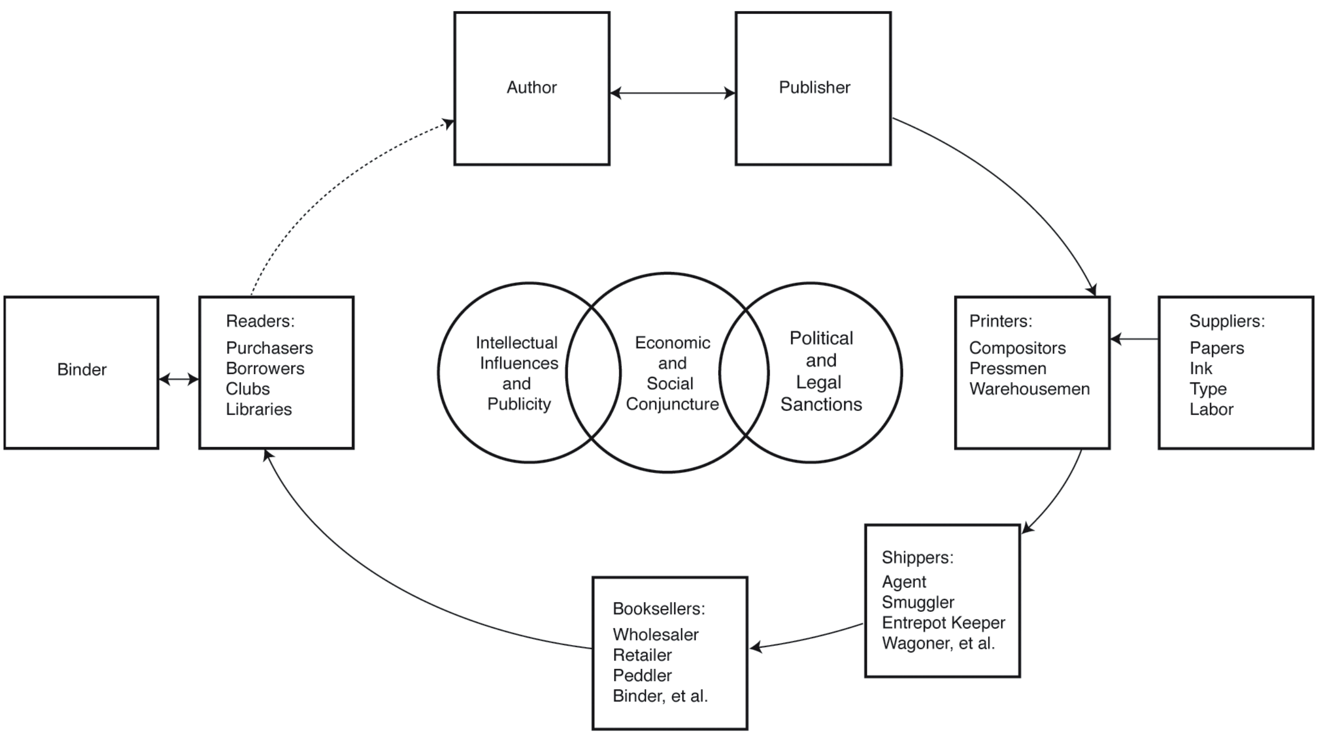

FIG. 184. THE COMMUNICATIONS CIRCUIT.
After Darnton 1982, 68 (fig. 1).

mapsellers located along the rue St. Jacques on the Left Bank of the Seine. This distribution, which remained largely unchanged between the mid-seventeenth century and the 1790s, was the result of city laws, trade restrictions, and the desire to be near instrumentmakers, other associated trades, and the customers frequenting the university and the law courts. The business and social world that revolved around the shop on the quai de l'Horloge of the leading mapmakers Gilles Robert Vaugondy and Didier Robert de Vaugondy was, like that of their many counterparts, one of engravers and printers on the move, of customers perusing and purchasing, of manuscript maps, half-finished copperplates, and unbound atlas pages circulating the Parisian streets (Pedley 1981, 1992).

There was also a growing trade in maps between London and Paris and between other urban centers of consumption, indicating international networks of map exchange and use. Letters written by European mapsellers to the London firm of Thomas Jefferys and William Faden between 1773 and 1783 show the import rate of maps into London to be much greater than the export rate, a reflection of customer demand and of "the desire of London map makers to own foreign maps as resources for their own production" (Pedley 2000, 2). Mapsellers' shops were thus local nodes in international circuits of consumption: simultaneously places to view the latest maps, sites for conversation and sociability, spaces for the exchange of information as well as of money, and production sites where, behind the scenes, new maps were being drawn up or others' work assessed. Mapsellers' catalogs and, increasingly importantly throughout the eighteenth century, newspaper advertisements, would indicate what was available. For example, publisher and mapseller Pieter van der Aa's 1715 *Catalogue de livres, de cartes geographiques* listed new maps published in France, Germany, England, and elsewhere just arrived in his Leiden shop, detailed the different map sizes or the weight of paper on which they were produced, and, for some items, emphasized ornamental value rather than accuracy—all in order to appeal to different sectors of the market. So readily available were maps at the beginning of the eighteenth century that the German-speaking market was even provided with a kind of reader's guide to help them choose among the offerings (Gregorii 1713).

Recognizing in general that "by the eighteenth century, maps and globes had become a regular feature in the life of the literate" (Pedley 2005, 6), it is also possible to see different types of maps in use in different ways in different places and circumstances and, from this, to note social and geographical particularities in the consumption of maps. Maps for use in military campaigns, for example, needed to be accurate in their depiction of the country and suited to outdoor use by an army on the move. *The American Military Pocket Atlas* of 1776—subtitled "being An approved Collection of Correct Maps, both general and particular, of The British Colonies; Especially those which now are, or probably may be The Theatre of War"—was known colloquially as "The Holster Atlas" since it was, as its "advertisement" made clear, designed to suit military uniforms (and budgets): "Surveys and Topographical Charts being fit only for a Library, such Maps as an Officer may take with him into the Field have been much wanted. The following Collection forms a Portable Atlas of North America, calculated in its Bulk and Price to suit the Pockets of Officers of all Ranks" (vii).

The appearance of maps in periodicals, after 1731 in the case of the London-based *Gentleman's Magazine*, meant that the public could follow military campaigns at a distance and even learn of the work of the French-led geodetic expeditions in Peru (Reitan 1985). Later in the century, maps of the world appeared, "exhibiting the track of several modern Navigators" (*Gentleman's Magazine* 1773, 43:590). In such ways, the reading public could locate current affairs in a rapidly changing global context. In colonial British North America, the leading mapmaker Lewis Evans marketed different impressions of his maps to suit a range of customers and uses. His *A General Map of the Middle British Colonies* of 1755 was one of the most important printed maps covering that region because of its contribution to new knowledge and because of the military, commercial, and political use made of it and the many pirated editions (see fig. 235). Earlier, Evans had advertised the second edition of his 1749 *Map of Pensilvania, New-Jersey, New-York, and the Three Delaware Counties* at different prices and qualities, even allowing users of earlier or damaged maps to exchange old for new: "The Price of the Plain Maps is *One Spanish Dollar*; of the colour'd Ones, on superfine Writing-paper, *Two Dollars*; and there are a few on fine Calico, at a *Dollar* and a *Half* each. In Justice to the Buyers of the former Impression, their colour'd Maps, tho' torn or defaced, will be exchanged for the new Edition at *Five Shillings*, and their plain Ones at *Two Shillings* and *Six-pence*" (*New-York Gazette Revived in the Weekly Post-Boy*, 17 August 1752). A study of the consumption of cartographic products in eighteenth-century North America reveals that maps were owned not only by attorneys, clergymen, mariners, and merchants, but also by artists, brickmakers, tailors, and even tavern keepers (Bosse 2007).

Map and globe use was extensive in schools, universities, private academies, and teaching at home. Most books of geography and instructional guides in navigation and astronomy began with a section on the use of maps and globes in order to understand geography as a science and its relationships to cosmography and chorography, the practice of regional description. The consumption of maps in an educational context, in schools or in map use and teaching at home, was thus commonly associated with the use of texts and instruments, notably celestial and terrestrial globes but also the armillary sphere or orrery (fig. 185; and see fig. 188). Maps were used to teach civil history, mathematics, astronomy, and ancient and modern geography and to locate natural phenomena such as trade winds, ocean currents, major rivers, and topography. Map drawing—making and using one's own map—was less common, although map preparation was taught in public geography classes and at some universities as a form of practical mathematics. In more specialist institutions such as naval and military academies, topographic maps and plans were used to teach the theory of fortifications, as a means to "read" the landscape from a military point of view and to instruct trainee officers and military engineers in the particular color conventions associated with military mapping. To an extent, then, it is possible to discern gender differences in map use, or at least differences in exposure to maps in given social settings. Map use in some contexts—military engineering, canal building, and hydrography, for example—was a wholly male preserve. But in teaching geography in schools and, in the home, using embroidery, for example, to stitch map outlines and so learn about a nation's outline (Tyner 2015) or in reading maps in periodical literature and there following the affairs of the time, women had occasion to use maps in several ways, if not always in the same social spaces as men.

FIG. 185. MAP USE IN AN EDUCATIONAL SETTING. Frontispiece to volume 1 of Nicolas Lenglet du Fresnoy, *Méthode pour étudier la géographie,* 3d ed., 7 vols. (Paris: Rollin Fils, Debure l'Aîné, 1741–42).
Image courtesy of the Bibliothèque nationale de France, Paris.

The use of maps—and even their misuse—in association with text and instrument use was a form of literacy as well as of technical competence. Students in the University of Edinburgh in the 1690s, for example, prepared maps of local buildings while being instructed in Newtonian mathematics by leading mathematician David Gregory. These student maps were later displayed in the library. In June 1698, the University librarian was chastised by the authorities for letting students remove a volume of Willem Jansz. Blaeu's *Atlas maior* and damage the maps of Scotland in doing so (Withers 2005, 300–301). Maps, then, could be used in teaching, for the purposes of display and, in Edinburgh at least, could become public objects through the negligence of librarians. We should not straightforwardly assume, however, that maps or atlases were understood and used simply to reflect the world exactly or unambiguously. The leading London mapseller Faden addressed exactly this problem intrinsic to map use in his *Geographical Exercises* (1777). Faden noted how pupils were taught to begin the study of geography with "the Use of the Globes, and then they proceed to that of Geographical Maps." While no globe could have illustrated the issue, Faden wanted his readers to be aware of the continuing debate about the shape of the world: "that abstruse Problem respecting the spherical Form of the *Earth*" (Faden 1777, preface). A further difficulty was the fact then that no single prime meridian had yet been settled upon for all maps: "But in order to ascertain and determine Longitude exactly, it has been necessary to adopt a *primitive Meridian*, from whence is computed the difference of the distance between one place and another. . . . Each Nation having chosen its first Meridian, has occasioned no small confusion in Geography" (Faden 1777, 1–2). Despite these difficulties, "the Maps contained in this Work may be laid successively before the Pupil, at the same time requiring him to draw upon the Sheets corresponding to each Map, the Subject of the Lesson assigned him by the Master, or proposed by himself" (Faden 1777, preface).

Although map consumption reflected broader patterns of consumer consumption driven by heightened individual purchasing power and national mercantile and industrial wealth, we should not think of map use only or even principally in economic terms. "Use," "usefulness," and, in this period particularly, "utility" were terms associated with private and individual betterment and with sociability rather than with notions of exchange value and economic return alone. Maps were used to educate and to train, but they were also used to amuse and to instruct through play. Similarly, the combined use of maps and instruments did not always mean that they were understood as scientific devices. Maps in the form of needlework samplers encouraged female dexterity and proper comportment as they provided geographical instruction. A heightened attention to map use in local history and in the study of ancient geography underlay a rise in map collecting: use not in a functional economic sense but as part of an emergent antiquarianism. Maps were a major part of the many geographical games popular in the eighteenth century. In the abbé Gaultier's *A Complete Course of Geography, by Means of Instructive Games* (2d ed., 1795), geography was taught using "common maps" (that is, annotated), "plain maps" (with outlines only), and sets of counters with the names of kingdoms, provinces, islands, seas, and rivers marked on them that the student, from memory of the common maps, placed on the plain maps. A popular form of instructional geographical game and a particular form of map use involved the geographical jigsaw, or, as John Spilsbury, the leading maker in England, described them, "dissected maps." Spilsbury, self-styled as "Engraver and Map Dissector in Wood, in Order to Facilitate the Teaching of Geography" and apprenticed to Jefferys in London between 1753 and 1760, died at age thirty in 1769. He was nevertheless an influential producer of "dissected maps" and other geographical games through whose use, in the home and at play, the countries of the world could be shown to fit together (Shefrin 1999, 7–8).

Map use in its many forms provided the basis for what may be thought of as "cartographic literacy," an increased exposure to and an understanding of the nature of maps, of what they could do as textual documents, and of mapping as an intellectual, technical, and social process. Cartographic literacy varied by social rank and by need. It reflected access to maps and print culture in general since although maps as commodities were more commonplace later in the eighteenth century than earlier, not everyone could afford to buy them, knew how to read them, or understood their symbolic language. A pair of globes, celestial and terrestrial, may have been useful alongside maps for teaching astronomy or in tracing the routes of oceanic navigators, but they were costly items: what was a necessity in one context (in navigational training, for example) was a luxury in another (globes as objects of domestic display and cultural status).

The expanded use of maps for administrative purposes both reflected and directed the growth of nation-state politics and, for those European countries with overseas dependencies, the use of maps as forms of territorial surveillance was essential to successful colonial governance. The use of estate maps and cadastral plans in law and in local politics helped delineate social and physical boundaries. The idea and the result of the map-as-survey brought together the overview of terrestrial space as property with the authority of the mapmaker and the viewer to inscribe that space (and, simultaneously, to exclude items from representation on the map) and thus further established connections between people and place and between map use and geographical identity. Martin Brückner stresses these interrelationships between map use, cartographic literacy, and what we may think of as a "geographic culture of letters" in tracing the emergence of national identity in the early United States. For Brückner, map use—taking that term to mean preparing and working with maps and "plats" (plots) of colonial land, reading maps in books of geography such as Jedidiah Morse's *Geography Made Easy* (1784), and more influentially his *The American Geography: Or, A View of the Present Situation of the United States of America* (1789), and mapping as a form of narrative placement—was critical to the emergence of a single national identity. Using maps in these ways allowed the people of a nascent America to chart themselves as a nation, to delimit their relationship to frontiers both natural and political, and to see where they stood in regard to native peoples (Brückner 2006).

Map history perhaps privileges the production of maps over their consumption, seeing in the former a narrative combining the intellectual mastery of geographical and celestial space, affiliation between trades and progressive technical accomplishment, and treating maps' existence rather more than their use as reasons to study them. We must recognize that the two terms must be seen in relation one to another and not as separate; the consumption of maps is part of diverse social and cultural histories more than it is of scientific and technical histories. Map use was borne of greater familiarity with maps as objects in everyday life: at home, in the classroom, on the walls of financial institutions and trading companies, in the pockets of engineers and soldiers, and in the rooms, corridors, and administrative imagination of institutions of government. The meaning of a map could be transformed by the different needs of its consuming audiences and by the different social spaces in which it was read and used. Lines and symbols on sheets of paper prompted plans for action. Consumption of a map commonly led map readers, and mapmakers, to inscribe and describe one's world anew.

CHARLES W. J. WITHERS

SEE ALSO: Allegorical and Satirical Maps; Atlas; Education and Cartography; Games, Cartographic; Geography and Cartography; Globe; Household Artifacts, Maps on; Map Collecting; Map Trade; Property Map: Estate Plan; Public Sphere, Cartography and the; Wall Map; Women and Cartography

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Cook, James. James Cook was born 27 October 1728, Marton-in-Cleveland, North Yorkshire, England, and married Elizabeth Batts 21 December 1762 (six children); he was killed 14 February 1779 at Kealakekua Bay, Hawaii. Cook is "still commonly regarded as the greatest sea explorer of all time" (Thomas 2003, xx), albeit one who has also been viewed as an agent of empire as well as a brilliant navigator and "great dispeller of [geographical] illusion" (Beaglehole in Cook 1955–74, 4:698). He made a significant contribution to the cartography of the Enlightenment. As a result of his three Pacific voyages between 1768 and 1780, he redrew the map of the Pacific Ocean much as it remains today. He sailed with teams of specialists—astronomers, surveyors and chartmakers, artists, and civilian naturalists (most notably Joseph Banks and Johann Reinhold Forster)—and their collective story was disseminated throughout Europe in official voyage narratives that were based on Cook's record of events. These publications were regarded as seminal events of the Enlightenment, having a significant impact on European art and aesthetics, literature, and science. They posited a new era of scientific travel and writings based on ideals and practices of first-hand and impartial observation, precise measurement, descriptive realism, and comparison and classification.

Cook first went to sea in 1747, serving nine years in the North Sea coal trade in the employ of Whitby merchant John Walker, thus gaining valuable experience in seamanship and navigation. In 1755, when about to be given command of one of Walker's ships, Cook surprisingly enlisted in the Royal Navy as an able seaman. In 1757 he passed the Trinity House examination for master, which put him in charge of ship navigation and the daily routine. Cook spent most of the Seven Years' War in eastern Canada, where his interest in hydrographic surveying was fostered. Together with Samuel Holland, he constructed a chart of the Saint Lawrence River that enabled the British to reach Quebec in 1759. Between 1763 and 1767 he undertook a detailed survey of the coasts of Newfoundland and published the charts privately; in 1775 they were included in the *North American Pilot* (Skelton 1965). In 1767, an expedition to the Pacific Ocean was planned by the Royal Society to observe the transit of Venus across the face of the sun and thus calculate more accurately the distance between the earth and the sun. The society selected Alexander Dalrymple, but he would only go if given command of the ship, to which the Admiralty was implacably opposed. Between 5 and 12 April 1768 the remarkable decision was made to appoint Cook, who at that time was only a master in the Royal Navy—all previous voyages to the Pacific had been commanded by a post captain (Beaglehole in Cook 1955–74, 4:126–27).

Cook sailed for the newly discovered island of Tahiti and, having completed the observations, as further instructed, he sailed to 40°S in search of the supposed southern continent, or *terra australis incognita*—a continent thought to balance the landmasses of the Northern Hemisphere. This speculative idea had been revived during the mid-eighteenth century, notably by Dalrymple and Charles de Brosses. When Cook failed to sight land he sailed south and then west to the land (now New Zealand) sighted by Abel Tasman in 1642 to ascertain whether it was part of the southern continent. Having made a running survey of the coastlines of New Zealand, Cook then surveyed the whole of the unknown east coast of New Holland (now Australia) and sailed through the Torres Strait, which confirmed the separation of Australia from New Guinea.

Cook realized he still had not clarified the existence or otherwise of the southern continent, but his second voyage (1772–75) produced a clearer outcome. After three ice-edge cruises that took him to 71°10′S, he wrote that he had voyaged "not only farther than any other man has been before me, but as far as I think it possible for man to go" (Cook 1955–74, 2:322). He was satisfied that no land existed at that latitude, although this outcome did not prevent further exploration. He charted numerous islands and coasts along the way, including New Caledonia, the New Hebrides/Vanuatu, the Tongan Islands, Society Islands, Marquesas Islands, and Easter Island. Cook himself recognized that there were close links between his exploration and empire (Cook 1955–74, 2:322). Indeed, he was instructed to take possession of favorably positioned and apparently vacant lands and to suggest new avenues of trade.

One major cartographic conundrum still existed. Cook's third voyage (1776–79), for which he was recalled from semiretirement, was to confirm or disprove the long-supposed existence of the Northwest Passage, a sea route connecting the North Pacific and the North Atlantic; the Pacific entrance was placed by French and Russian maps around 65°N. After calling at New Zealand, Tonga, and Tahiti, Cook sailed into the North Pacific and in January 1778 became the first known European discoverer of the Hawaiian Islands, the scene of his dramatic death later in 1779. He then headed for the northwest coast of America, exploring Nootka Sound, Prince William Sound, and Cook Inlet. He consulted maps he had on board by Gerhard Friedrich Müller and Jacob von Stählin depicting the earlier Russian discoveries but found them highly erroneous. In August 1778 he passed north through Bering Strait but was forced back from further exploration eastward and westward by the ice.

Cook wrote remarkably little about his methods of surveying and chart construction, and, as Andrew David (1988–97) shows, drew far fewer of the surviving voyage charts and coastal views than, until recently, was commonly thought. He frequently delegated this essential task (including the production of fair copies of his draft charts) to officers he trained and trusted, such as Isaac Smith, William Bligh, and Henry Roberts. Depending on the nature of the coasts concerned and the task to be done, Cook decided and oversaw the surveying: this might be running surveys of long coastal stretches (e.g., New Zealand, the eastern Australian coast, and the northwest coast of North America; fig. 186) in which observations of prominent coastal features were made largely from the ship (ship stations), and distances traveled along coastlines were measured by a log line. These observations were entered on daily (noon to noon) survey sheets and incorporated into compilation sheets to scale that were usually drawn on a Mercator projection. Others were sketch surveys of islands, atolls, harbors, rivers, and anchorages. In some cases astronomical observatories were set up on shore and a greater range of survey equipment deployed, which produced charts that were usually on the plane projection, ungraduated, and at a variety of scales down to 1 inch to 1 mile (1:63,360); these showed a greater range of topographical and nautical information (David 1988–97, 1:xxvii–xxxiii, 2:xxix, 3:xxvi). The basis for these methods was probably the most commonly available manual, John Robertson's *Elements of Navigation* (1754), which ran into many editions throughout the century.

Cook's teams also proved the utility of the use of chronometers for the calculation of longitude on the second and third voyages. This practice, together with the astronomical method of establishing lunar distance using the astronomer royal Nevil Maskelyne's yearly *Nautical Almanac* (first published for 1767), meant that Cook's surveying and mapping were very accurate as to both latitude and longitude.

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SEE ALSO: Marine Charting: Great Britain; Northwest Passage; Pacific Voyages

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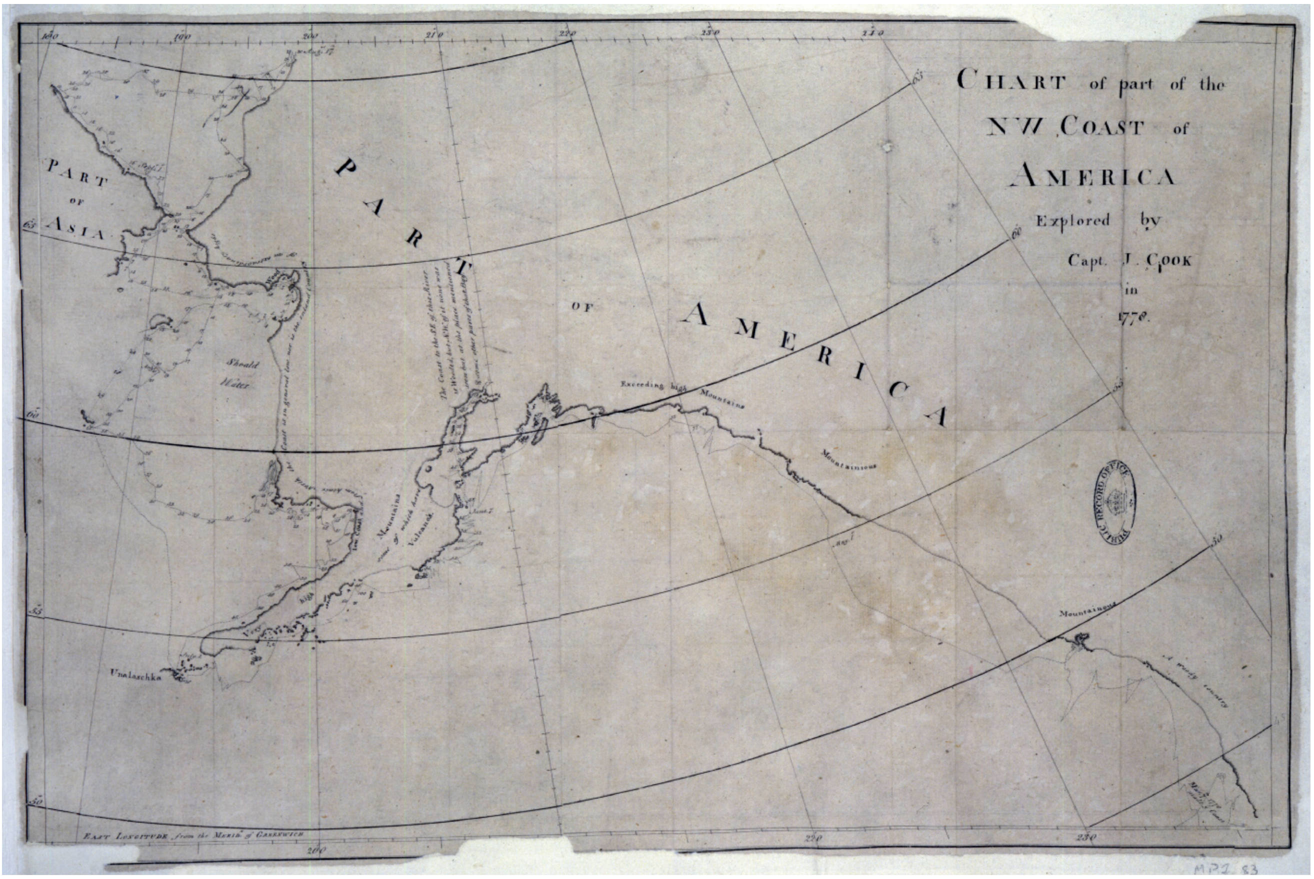

FIG. 186. JAMES COOK, "CHART OF PART OF THE NW COAST OF AMERICA, EXPLORED BY CAPT. J. COOK IN 1778." Cook enclosed this manuscript chart in his letter of 20 October 1778 from Unalaska to the secretary of the Admiralty in London, where it was received 6 March 1780. The map shows the track of the *Resolution* and *Discovery* from their first landfall on North America (7 March) to Cook's return to Unalaska in the Aleutian Isles (3 October).
Size of the original: 30.0 × 45.5 cm. Image courtesy of The National Archives of the U.K. (TNA), Kew (MPI 1/83).

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Coronelli, Vincenzo. A Franciscan Conventual friar, Vincenzo Coronelli became well known for building a pair of giant globes for King Louis XIV (1681–83), later exhibited in the royal palace of Marly (1704). Having returned to Venice in 1683, he published terrestrial and celestial maps, atlases, globes, and illustrated books. A favorite of Pope Innocent XII, he was elected superior general of his order in 1701, but in 1704, Pope Clement XI removed him from office because of his poor relations with fellow friars, resulting from accusations of misused funds. After that, Coronelli lived in the Venetian Convento dei Frari, where he established a small engraving and printing house and sold guides of Venice and reprints of maps and views; he also tried to reinvent himself as an expert in hydraulics. When he died, 9 December 1718, all his copperplates were sold for roofing and drain pipes to pay his publishing firm's many debts.

Born in Venice on 15 August 1650 into a family of poor artisans and baptized Vincenzo Matteo Coronelli, he studied in his order's school in Venice and graduated in theology at the Franciscan college of San Bonaventura in Rome. Later, in Venice, he trained as a mathematical practitioner. In 1679 he prepared a pair of large globes for the duke of Parma, about which we know nothing.

Yet when the French representative to the Vatican, Cardinal César d'Estrées, saw them, he invited Coronelli to Paris. There Coronelli executed the famous globes for Louis XIV: two spheres, four meters in diameter, built and prepared by a highly skilled team of Venetian carpenters and draftsmen. These globes constituted a remarkable compilation of the latest astronomical and geographical information based on Dutch and French models of the mid-seventeenth century, further enriched by important new information gleaned from the archives of the French ministries and the Académie des sciences. The splendidly original figures of the constellations painted in the usual convex form on the celestial globe were the work of Jean-Baptiste Corneille, Arnould de Vouez, and other members of the *atélier* of the king's painter Charles Le Brun (see figs. 175 and 182). Profiting from the privilege granted him by the French king, Coronelli continued to reproduce the design and contents of the king's globes up to 1698. Though beautiful, these later works suffered from poor engraving, hasty editing, and the lack of relevant astronomical or geographical updating.

Coronelli's publishing career in Venice began with printed maps of Dalmatia (1684–89) and what might be called instant news books about places where Venice was then fighting the Turks, illustrated with crude engravings of sometimes outdated maps and fortress plans. In 1685, to support his intended publication of an *atlante veneto* (Venetian atlas), the Senate gave him the title of *cosmografo della Repubblica*, a pension, and later a public teaching chair in Venice. In 1690 he published the first volume of the *Atlante veneto*, modeled on Joan Blaeu's *Atlas maior* (1662), containing cosmography, maps of the continents, and hydrography (maps of oceans and great rivers and drawings of ships and boats). He planned the subsequent volumes in the same Dutch style—maps of all the countries of the world coupled with texts. These never appeared. Instead, using the same general overarching title *Atlante veneto*, Coronelli published two volumes of his geographical and chorographical maps in the French style with no text (*Corso geografico universale*, 1692); a two-volume atlas of islands (*Isolario dell'Atlante veneto*, 1696–97); and a marine atlas (*Specchio del mare*, 1698), printed from the plates and the text of the Genoese edition of a Dutch prototype. From 1697, he also sold the printed gores of his globes in atlas format under the titles *Globi del P. Coronelli* and, after 1705, *Palestra litteraria* (fig. 187). He prepared custom-made atlases of city and fortress plans (*Città e fortezze*, 1693), portraits of patrons and members of his subscription list (the Accademia Cosmografica degli Argonauti), and plates of ships and boats taken from the first volume of the *Atlante* (and published as *Navi o vascelli*, 1697). He put all these publications on the market as a part of the *Atlante veneto*. By 1698 the *Atlante veneto* boasted thirteen volumes, but only 250 of its large copperplates were original.

In 1686 Coronelli began to produce reduced versions (108 cm diameter) of the Paris globes. The terrestrial globe was made in Venice between 1685 and 1688 and never changed except for its dedicatory cartouche. However, after 1701 its extra-large copperplates were cut in two. The gores for the celestial globe were entrusted to the Parisian engraver Jean-Baptiste Nolin (1686), but the plates, probably not paid for, were never returned to Italy. In 1693 Nolin published the celestial globe in Paris (globe of the "Societas Gallica," which paid for its printing). Meanwhile Coronelli marketed a novel 108-centimeter celestial globe, engraved in Venice (1692). It was advertised, somewhat incorrectly, as a "sky view," or concave, globe, although the gores were pasted on the exterior surface of the sphere, not the interior, as would be expected. This is written on a cartouche on the 1692 globe: "Dear reader, this globe represents the constellations of the firmament as we see them with our eyes, not as on the other globes, because to understand them we must imagine that we are at their center." Moreover, the figures of the constellations are shown in mirror image: the human figures continue to turn their backs to the spectator, but their poses and gestures are reversed, left to right, as in a mirror.

To accompany the globe, Coronelli published the *Epitome cosmografica* (1693), containing a star catalog and rudiments of astronomy, geography, astrology, and globe use. In 1699 he published another celestial globe of the same size, in convex form (known as the globo Ottoboni). Both Venetian globes imitate the Nolin engravings but with errors and omissions. Coronelli also reproduced the original globe pair in ever-smaller sizes (ca. 46, possibly 33, 15, 10, and 5 cm diameter). In 1701 he published the first volume of a forty-volume encyclopedia (*Biblioteca universale sacro-profana, antico-moderna*), but its enormous cost stopped production at volume seven in 1708, definitively ending his career as an international publisher.

For more than twenty years, Coronelli's globes and maps sold well to princes, aristocrats, and high-ranking ecclesiastics, mainly in Italy and Germany. Nevertheless, his work did not win praise from active members of Europe's scientific academies, whose names are notably absent from the Accademia degli Argonauti. By the time of his death Coronelli was almost forgotten. His works were rediscovered only around 1940; the tercentennial of his birth in 1950 began a revival, sometimes bordering on a cult, accompanied by overabundant literature, which was not always based on correct or firsthand information.

Coronelli's career relied on the patronage of princes,

FIG. 187. DETAIL FROM CORONELLI'S PRINTED TERRESTRIAL GLOBE, VENICE 1688. From Coronelli's *Palestra litteraria* (Venice, after 1701), pl. 50. Copper engraving on paper. Later state, after 1705 (the copperplate of the half gore is cut along the Tropic). The reference to Venetian voyagers and writers was added in the printed globe to flatter the pride of the Republic.

Diameter of the original: 108.0 cm; size of detail: 21.7 × 27.7 (top) 25.0 (bottom) cm. Image courtesy of the John Carter Brown Library at Brown University, Providence.

to whom he offered not only globes and maps, but also designs for weapons, mud-dredgers, breakwaters, floodways, and church façades. He was a mathematical practitioner in the style of the sixteenth and seventeenth centuries, and not one of the best: his main skills were in empirical mechanics; his science was secondhand and derivative. As a publisher, he was short-lived. He owed his success mainly to the strenuous pursuit of the favor of princes, to tenacious self-advertisement, and to the prevailing culture of curiosity. His large globes in particular were curiosities because of their royal origins and their outsized dimensions, unusual for printed globes. Moreover, they responded to fashionable curiosity about nature and man, and they sold at reasonable prices. Coronelli was a master of the mechanics of globemaking and at ease with the necessary standard geographical and astronomical knowledge, but his work displayed no innovation. Instead he placed new information in a beautiful but increasingly outmoded framework.

MARICA MILANESI

SEE ALSO: Celestial Mapping: Italian States; Constellations, Representation of; Globe; Map Trade: Italian States

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Cosmographical Map. A learned natural philosopher is lecturing on the orrery to illustrate the positions and motions of the planets in the solar system (fig. 188). His audience is in contemplation of the miracle of modern science and the wonders of the universe. A man is taking notes. Other figures, including a woman and three children, follow the demonstration, gazing at the mechanical device. A lamp, hidden behind the boy in the foreground, represents the sun in the center of the solar system. The flame of the candle plays over the faces in the picture, seemingly to demonstrate the main phases of the moon. Joseph Wright of Derby, the author of this canvas, has been described as the first painter to express the spirit of the Industrial Revolution. This provincial artist was also witnessing around him the Scientific Revolution. Like many in the age of the European Enlightenment, Wright believed in progress, was thrilled by the exploration of the unknown, and trusted that men could be made better through education.

Orreries were three-dimensional counterparts of cosmographical maps. Cosmography, according to many encyclopedia and dictionary entries, describes the gen-

FIG. 188. JOSEPH WRIGHT, *A PHILOSOPHER GIVING A LECTURE ON THE ORRERY* (1766). Size of the original: ca. 147 × 203 cm. Bridgeman-Griaudon/ Art Resource, New York.

eral features and disposition of the universe, including heaven and earth. Cosmographical maps portray the spatial organization of the material universe, allowing a perspective similar to God's. By Wright's time, however, an entirely new image of the cosmos had replaced the traditional conception created in ancient Greece, incorporated into Christian lore, and dominant in the West until a century earlier. Aristotelian-Ptolemaic cosmography affirmed the existence of a finite, spherical cosmos centered on an immovable earth. Nicolaus Copernicus's heliocentrism, Johannes Kepler's laws of planetary motion, Isaac Newton's theory of universal attraction, Giordano Bruno's speculations about the infinity of space, Galileo Galilei's use of the telescope to observe the stars and his attempt to apply mathematics to the study of movement had all brought about a new conceptualization of the universe, fitting for the Age of Enlightenment. The Aristotelian division between the sublunary and the superlunary spheres (altogether different in nature) was abandoned on the assumption that celestial and terrestrial phenomena were subject to the same laws of nature. Between 1650 and 1800 scientists developed an interest in these laws and tried to obtain reliable data and precise measurements. Cosmographical societies and scientific academies, often with royal patronage, were founded throughout Europe, and museums of science began to emerge. Contemporary maps presented the universe as a system of celestial mechanics, showing the complexity of planetary motion. The scientific study of the earth's shape and size and the mapping of geographical data increasingly depended on astronomical observations and calculations, as is shown by the most prominent scientific issue of the eighteenth century: the determination of longitude.

Maps displayed the world in its astronomical context, conveying the articulation of the boundaries of modern knowledge. Maps of the earth, for instance, were drawn with a scientific (rather than artistic) purpose: the borders of maps of the world drawn as double hemispheres were often filled with scientific information (texts or charts) about the heavens or about various natural and celestial phenomena, setting the earth within its context in the solar system (for example, maps by John Seller [1673], Frederick de Wit [1705–6], and Adam Friedrich Zürner [1710]). Personifications were adopted to indicate the four seasons, as in a number of double-hemisphere late-seventeenth-century maps by de Wit and Gerard Valk. The invention of the telescope allowed detailed lunar maps. Mapmaking in the Enlightenment merged astronomy and geography in a new fashion, producing an intellectual construction that has been described by historians of cartography as "mathematical cosmography" (Edney 1994). It was based on the belief in the cosmological unity of the earth and the heavens. Moreover, in tune with the scientism of the period, cartography was seen as a progressive and objective activity. The process of democratization opened new markets for maps as improved standards of mapmaking supported the mapmaker's ambition to produce scientific documents.

Yet not all maps of the cosmos were secular in character. Some displayed a strong religious element. The borders of *A Map of All the Earth and How after the Flood It Was Divided among the Sons of Noah*, designed by Joseph Moxon in the late seventeenth century, for example, were illustrated with biblical scenes, a confirmation that cosmography could include chronology, structuring not only space but also time. Some of the new scientists were committed Christians, believing in the universe as a designed mechanism and in God as its designer. There were a number of different "enlightenments" and differences among European nations, and "cosmography" meant different things to different people.

ALESSANDRO SCAFI

SEE ALSO: Astronomical Models; Celestial Mapping; World Map

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Covens & Mortier (Netherlands). In the eighteenth and first half of the nineteenth centuries Covens & Mortier, 1685–1866, was the most important Dutch publishing house in the field of commercial cartography and possibly the biggest contemporary map-trading house worldwide (Van Egmond 2009). Pieter Mortier founded the company in Amsterdam first as a bookseller but soon began publishing voluminous atlases. In 1706 he had a new home built on the Vijgendam, where, for over a century, the major trade activities were conducted. Pieter was succeeded by his widow, Amelia 's-Gravesande, and by his brother David Mortier. From 1721 Pieter Mortier's son Cornelis ran the firm together with his brother-in-law Johannes Covens. Later firm members were Johannes Covens Jr., Cornelis Covens, and Cornelis Joannes Covens. Under the last owner the firm moved to the Nieuwendijk in 1828 and to Rusland

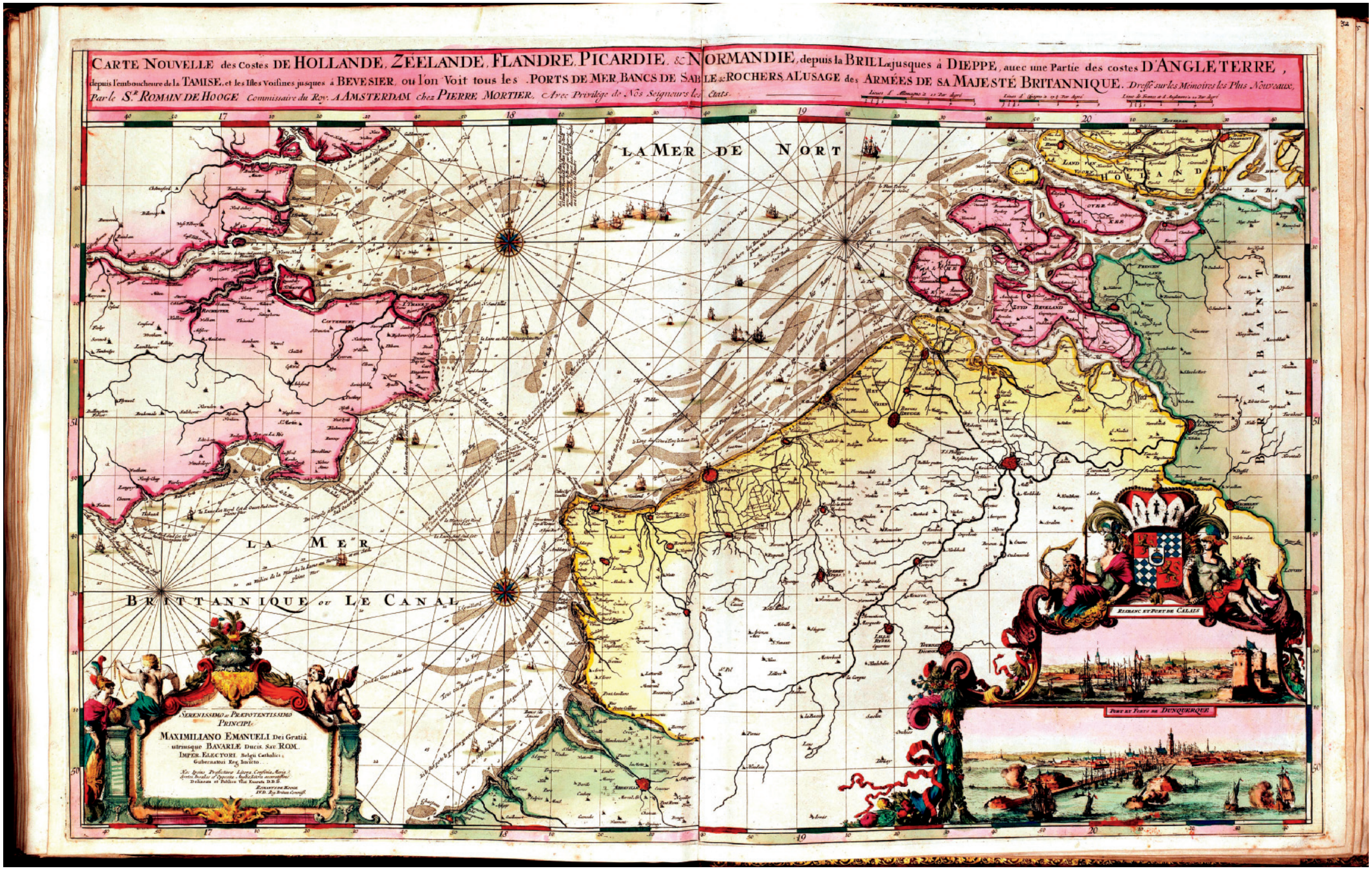

FIG. 189. ROMEYN DE HOOGHE, *CARTE NOUVELLE DES COSTES DE HOLLANDE, ZEELANDE, FLANDRE, PICARDIE, & NORMANDIE*, PUBLISHED BY COVENS & MORTIER IN *LE NEPTUNE FRANÇOIS*. This Dutch edition was titled *De Fransche neptunus*, ed. Charles Pène (Amsterdam: Pieter Mortier, 1693). Size of the original: 58 × 95 cm. Image courtesy of the Universiteitsbibliotheek Amsterdam (Bijzondere Collecties, OTM: HB-KZL V 9 X 10[1], chart 31).

Street in 1857. In late 1866 Cornelis Joannes finally sold off his stock to the Amsterdam bookseller G. van Tijen & Zonen.

The firm of Covens & Mortier published books, prints, music, games, and ephemera such as booklets, bills, and invitations for music concerts, but the main focus was on maps. All sorts of cartographic material left the printing office, including wall maps, town plans, globes, town profiles, and geographical puzzles and games. The publishing of atlases formed, however, the major focus of cartographic activities. World atlases, for instance, were issued by Covens & Mortier in various formats, among them the big *Atlas nouveau* (1692–ca. 1790) after Nicolas Sanson and the *Atlas françois* (1695–ca. 1790) after Alexis-Hubert Jaillot. In addition, two historical atlases, a celestial atlas, the large sea atlas *Le Neptune françois* after the Académie des sciences and the Marine (fig. 189), a number of town atlases, and some pocket atlases and regional atlases were published (Van Egmond 2009, 93–139). Most atlases and maps published by Covens & Mortier were copies of foreign works or reprints of earlier, often seventeenth-century, Dutch copperplates. Only a handful of atlases and about 150 maps stem from original material, but most were of European and especially Dutch areas. The firm was not very selective in determining what to publish.

Initially, Pieter Mortier offered a varied and rather balanced selection of atlases and wall maps. The procurement of copperplates from other publishers, which started around 1705, led to a more arbitrary composition of the publisher's stock. The rather aggressive takeover policy of the firm seems to have originated from the desire to monopolize map production whenever possible.

Wholesale trade with domestic colleagues made for the larger part of the sales of Covens & Mortier. The firm began to act as a central Dutch map store, especially during the first quarter of the nineteenth century. Covens & Mortier made optimal use of the new system of trade on a commission basis—the desired, unsolicited shipment of commission products with the right of return—that replaced the old system of exchange. The well-stocked cartographic portfolio also catered to a market far in excess of domestic boundaries. Proven trade relations existed, for example, with English, German, Swiss, French, Italian, Polish, and Russian trade partners, and included David Mortier, Henry Overton and Philip Overton, and the firm of Jefferys & Faden in England and the Homann firm in Germany. By the end of the eighteenth century, however, the international sales of Covens & Mortier were diminishing considerably. The domestic market, on the other hand, was on the increase. Around 1800 Covens & Mortier finally monopolized the Dutch map trade. When the total production process is looked at in its entirety, from the collection of the base material until an atlas had been bound, at least twenty-five and at most forty-five employees must have been present in the firm's heyday. During the decline of the publishing house, from the second quarter of the nineteenth century onward, no more than five to ten people were at work in the houses at the Nieuwendijk and Rusland (Van Egmond 2009, 242).

No academic editors were employed on a regular basis. Commerce prevailed over quality of content and beating the competition over innovation. The firm was not, however, completely devoid of innovation. In addition to developing a new construction for a pair of globes and producing an improved topographical map image of Dutch regions, the firm was influential in other cartographic areas. For example, it introduced modern foreign map material on a large scale into the Netherlands. Furthermore, it produced *Le Neptune françois* and the *Atlas nouveau* in elephant folio format, which had never been used before for Dutch atlases. It also marketed in the first half of the eighteenth century a new systematic form of cartography—multisheet maps of areas where wars were taking place—the so-called theater of war series.

With its huge and diverse cartographic stock of about 4,000 items printed from about 5,000 copperplates, the firm acted as a driving force for the popularization of map use in Europe at the time. Most users of Covens & Mortier's maps must have had a general interest in geography and bought the maps for their personal use. Since the types of maps offered were a broad assortment and competitively priced (in part facilitated by the practice of copying), both wealthy and not-so-wealthy people could afford them, so that Covens & Mortier entered new European markets as more and more sections of the population became map owners. Cartographic material was no longer mainly restricted to a relatively small group of well-to-do citizens: in the eighteenth century it became a standard consumer product.

MARCO VAN EGMOND

SEE ALSO: Map Trade: Netherlands

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Cruquius, Nicolaas Samuelsz. Nicolaas Samuelsz. Cruquius (Kruchius, Kruikius, Krukius, Kruik), who occasionally used his initials to stand for the Latin phrase *neminem scientia cruciat* (knowledge tortures no one), is considered the most significant reformer of Dutch administrative cartography of the eighteenth century, with an influence that reaches far into the nineteenth century. Born on the Dutch isle of West-Vlieland on 2 Decem-

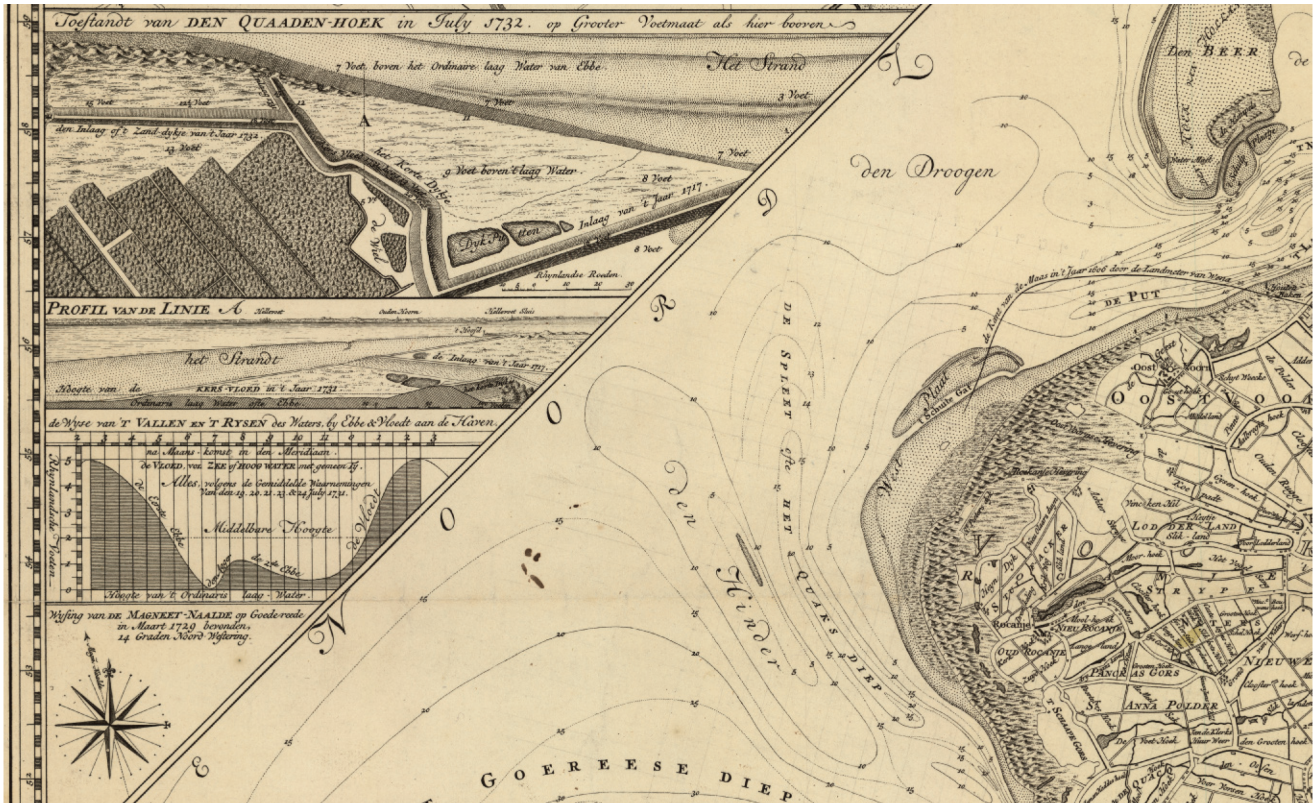

FIG. 190. DETAIL FROM NICOLAAS SAMUELSZ. CRUQUIUS, *HET EYLANDT WEST-VOORN OF GOEDEREEDE MET DE DIEPTENS EN DE DROOGTENS RONDS-OMME* (1733), 1:54,000. Detail from Cruquius's map of the island of Goeree and surrounding waters showing the insets depicting the endangered coast (with normal high tides and the inundations of 1717 and 1732), the pattern of the ebb and flow of the tide (measured in July 1731), and magnetic variation (measured in 1729). At right, the line arcing over the northern edge of the island indicates the coastline as it had been surveyed in 1606.
Size of the entire original: 65 × 55 cm; size of detail: ca. 24.5 × 48.5 cm. By permission of Pusey Map Library, Harvard University, Cambridge (G6002 G6 1733 C7).

ber 1678, he was raised in the city of Delft, where he worked from 1698 as a surveyor, cartographer, and meteorologist both on a private basis as well as in long-term employment with the Hoogheemraadschap van Delfland and the provincial administration of Holland. From 1733 until his death on 5 February 1754 he was stationed in the Dutch village of Spaarndam as a technical consultant to the Hoogheemraadschap van Rijnland. Cruquius earned a bachelor's degree in medicine at the University of Leiden. He was a member of the Royal Society in London and the Hollandsche Maatschappij der Wetenschappen in Haarlem in appreciation of his meteorological, astronomical, and hydrographical work, as well as for his tireless efforts to popularize experimental physics.

Cruquius's career received a great boost in 1701 when he and his brother Jacob Cruquius were entrusted with the surveying and mapping of the territory of the Hoogheemraadschap van Delfland, a commission that took over ten years to complete. The result was a grandiose wall map in twenty-five sheets at ca. 1:10,000 published by the *waterschap* as *T Hooge Heemraed-Schap van Delflant* (1712), in which he depicted the complex symmetry of these wetlands at an unparalleled large scale with a detailed display of ownership and landscape. Cruquius's desire to eliminate decorative elements may be seen in the individual sheets that make up the whole. However, the board of the Hoogheemraadschap van Delfland insisted on the sumptuous decoration in the borders surrounding the map as assembled. Thus, from a conceptual point of view the map probably reflected only part of Cruquius's original intent, but his patrons did not want to go along with his plan to use the map in formulating a research agenda that, in the long term, could resolve the water-related problems of Delfland and the province of Holland.

By 1705 Cruquius had already started meteorological and astronomical observations, a series of measurements that he continued until his death. Through this research, Cruquius was befriended by the famous Leiden physician Herman Boerhaave. Through Boerhaave's intercession, Cruquius was invited as an observer to the international meteorological network of the Royal Society of London, which convinced him even more that systematic observations would lead to the discovery of surprising astrometeorological connections. Between 1725 and 1727 this idea formed the focus point of a well-defined research proposal to the provincial administration of Holland to construct "a systematic scientific framework to observe the movement and changes of the air and the water" (Van den Brink 1998, 14–24, 203–9; quote on 203). Combined with an accurate topographical map, these observations were of vital importance for proper water management in Holland. While his proposal was considered too costly, Cruquius was invited to elaborate his wide-ranging perceptions in devising solutions for some key hydrographical problems in the Dutch river delta. This resulted in two imposing maps (1729–33), one of the Merwede River (see fig. 33) and one of the island of Goeree (fig. 190), in which he introduced several new cartographic concepts in depicting the dynamics of the river landscape, namely one of the first systematic uses of isobaths to indicate depths and endangered sea banks and river banks, the introduction of new symbols for identifying land use, as well as the induction of the results of meteorological, astronomical, and hydraulic investigation within the framework of the map.

After 1734 Cruquius led a reclusive existence as a technical consultant of the Hoogheemraadschap van Rijnland at Spaarndam, near the town of Haarlem. Although a serious eye disease increasingly limited his work, he continued to study the complex interactions between climate and landscape. The results of these examinations were worked out in a number of short articles that he shared and discussed with a small group of friends and pupils in Haarlem.

PAUL VAN DEN BRINK

SEE ALSO: Administrative Cartography: Netherlands; Heights and Depths, Mapping of: Isobath; Thematic Mapping: Netherlands

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Customs Administration Map. Customs administration maps illustrate customs structures and rules of a region or a specific territory. This type of map is especially prevalent in southern Germany. Similar to post-route maps, customs administration maps depict the network of roads reserved for the transportation of goods subject to duty as well as the customs offices and their branches. Typical examples include Matthäus Ferdinand Cnopf's *Geographischer Entwurf der . . . Zoll-Staette* (1763), Johann Franz Kohlbrenner's *Geographische Mauth-Charte von Bayern* (1764, 1768), and Johann Baptist Seitz's *Comercial Zoll und Maut Karte vom Königreich Baiern* (1807) (*Maut* was a standard term for customs in early modern southern Germany). The literature refers to them as *Mautkarten* (Schaup 2000, 311–14; Schlögl 2000, 2002), *Maut- und Zollkarten* (Kupčík 1995, 17–18, 118), *Mautstraßenkarten* (Leidel 2006, 281), or customs maps (Schlögl 1997).

The most important customs administration maps were published in the electorate of Bavaria between 1764 and 1769 (Schlögl 2002, 139–70). The example by Cnopf from 1763 that shows trade routes, boundaries, and customs offices around the imperial city of Nuremberg is not linked to them (Kupčík 1995, 17; Fleischmann 2000, 365). The Bavarian customs administration maps, published by the Augsburg firm of Tobias Conrad Lotter, were official, legally binding governmental publications. Whereas Cnopf designed his map to illustrate a regional customs situation in dispute, the Bavarian maps resulted from a fundamental renewal of the customs system in the context of late absolutist reform policy that emerged after 1745 to overcome the electorate's financial crisis. In 1765, a law established a centralized, uniform customs system in the country for the first time. In conjunction with the customs regulations and tariff tables, maps were used to illustrate all the spatial aspects of the customs system. Publicity and transparency were essential in the new customs law. Contrary to the earlier situation with locally differing and secret tariffs, the publicity of the improved system was intended to enable merchants to calculate in advance the amount of duties for which they would be liable. Additionally, the transparency of all rules was intended to ensure correct customs clearance and to protect travelers from arbitrary treatment by officials and thereby help to quickly establish the new system.

The customs map from 1764 was designed by civil servant Kohlbrenner, who later became well known as a leading representative of the Enlightenment in Bavaria, and was published in two formats for the quarto-print and the secundo-print editions of the customs law. The larger and more richly decorated of the two was probably also displayed in offices (fig. 191). The maps had similar contents, with a simplified geographical depiction based on the tradition of Philipp Apian on which were delineated both the rivers suitable for transport and the network of official trade routes drawn abstractly as straight lines. All customs offices are shown on the maps and listed in the left margin; the larger edition additionally contains information about transport capacities on the rivers. Road sections that had been developed to a particular paving standard (*chaussée*, or high road) were marked with short cross lines, and users of high roads had to pay a road usage fee in addition to customs tolls. The number of cross lines marking the relevant road section signified the amount of the road usage fee. In 1768, updated editions of both versions showing recently built high roads were printed by editing the old copperplates.

In 1769, a new customs system following the Bavarian model was adopted in the Upper Palatinate, a territory that was also ruled by the Bavarian elector but was still independent under constitutional law. Appropriate to the diverse territorial structure of the region, Kohlbrenner designed the customs administration map of the Upper Palatinate using a larger scale in order to give a more detailed depiction of boundary lines and to better

FIG. 191. JOHANN FRANZ KOHLBRENNER, *GEOGRAPHISCHE MAUTH-CHARTE VON BAYERN: VORSTELLEND ALLE ZU WASSER UND ZU LAND HERGEBRACHTE MAUTH-STATIONEN U. ACCIS-AEMTER SAMT DENEN DAHIN-FÜHRENDEN COMMERCIAL- U. LAND-STRASSEN* (AUGSBURG 1764). Large edition, copper engraving, ca. 1:650,000. The map visualizes all spatial aspects of the improved Bavarian customs system established in 1765.

Size of the original: 65 × 54 cm. Image courtesy of the Bayerisches Hauptstaatsarchiv, Munich (Kartensammlung 226).

distinguish the courses of trade routes (*Commercialstraßen*) from those of local roads (*Vicinalstraßen*).

A clear idea of the government's intentions to use maps as a medium to publish legal regulations emerges from the customs laws and orders and from the process of their development. As Franz Xaver von Stubenrauch, a leading Bavarian state economist who had conceived the new customs system, argued in advance, "a *Mauth-Charte* modeled after post-route maps or sea charts. . . . would show every trader or carter the required *terminum a quo, & ad quem* at only one glance . . . instead of reading multileaved descriptions. . . . Additionally, by means of this map the public would also gain insight into how far we have come in usefulness for the commerce with our roadwork. And incidentally, this delightful insight serves as the rule of how much toll has to be paid at each passage. In a word, we inform everyone with only one sheet what could hardly be explained understandably and clearly enough on ten sheets" ([Stubenrauch] 1792, 121–22).

The Bavarian customs administration maps are both a method and a result of enlightened reform policy and its economic program. Due to their legally binding nature, the maps formed an official depiction of the main road network and had to keep up with road improvements. Furthermore, they impacted roadwork administration, since the actual high road conditions had to meet the cartographically fixed state of a *chaussée* to prevent subjects and travelers from complaining against unjustified claims of toll. However, this dynamic process had not been foreseen, and the late absolutist Bavarian state was not strong enough financially and organizationally to sustain it. Plans to establish a close coordination of customs and roadwork administrations from 1769 onward were not realized. No further customs administration map was published until 1807, when Bavaria became a kingdom.

DANIEL SCHLÖGL

SEE ALSO: Administrative Cartography: Enlightenment; Thematic Mapping: German States; Transportation and Cartography: Road Map

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