13 · Chinese and Korean Star Maps and Catalogs

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Charting the stars is an undertaking entirely different from delineating terrestrial features such as continents and islands. Since the stars appear as scattered points of light, any attempt to divide them into groups must necessarily be subjective. The arbitrariness of such an exercise is increased by the wide range in brightness among the roughly six thousand stars that are estimated to be visible to the average unaided eye over the whole of the celestial sphere. It is thus remarkable that throughout history only two distinct schemes of astral cartography have enjoyed widespread usage. These are of Babylonian-Greek and of Chinese origin, and the latter system of astrography is the subject of this chapter.[1] Interaction between the various Eurasian cultures through the centuries has been largely responsible for restricting the development of other schemes of mapping the night sky. Nevertheless, the great differences that exist between the two major systems reflect their artificiality.

Although Chinese astrography has now passed into history (except at the popular level), in recent years there has been renewed interest in its scientific value. This development has largely resulted from growing appreciation of the importance of ancient and medieval observations of temporary stars (novas and supernovas) and comets—notably Halley's comet—recorded in Chinese history. The positions of these objects on the celestial sphere are often carefully described relative to specific star groups. With only isolated exceptions, Chinese observations of such phenomena have proved to be without equal anywhere else in the world before the European Renaissance.[2]

Several star maps and catalogs identifying the constituents of Oriental star groups in terms of their Western equivalents (for example, Bayer Greek letters or Flamsteed numbers) have been produced in China in recent years.[3] These works have largely superseded the well-known concordances of Williams, Schlegel, Wylie, Tsutsihashi and Chevalier, and latterly Ho.[4]

No detailed investigation of East Asian uranography has been published in a European language since the appearance of the voluminous work by Needham more than thirty years ago, which is still of considerable use today.[5] Two Chinese books on the subject that have appeared in the past decade or so are also frequently referenced in this chapter. The *Zhongguo gudai tianwen wenwu tuji* (Album of ancient Chinese astronomical relics) exhibits many fine photographs (some in color) of celestial charts and globes (as well as other astronomical artifacts).[6] It also provides brief but useful notes. The

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1. The system of Babylonian-Greek origin is discussed in other volumes of this *History*. The term "astrography" is a synonym for astral cartography. Another variant used elsewhere in this chapter is "uranography."

2. A detailed discussion of historical observations of supernovas, with special emphasis on Chinese records, is given by David H. Clark and F. Richard Stephenson, *The Historical Supernovae* (Oxford: Pergamon Press, 1977). For investigations of the history of Halley's comet see, for example, T. Kiang, "The Past Orbit of Halley's Comet," *Memoirs of the Royal Astronomical Society* 76 (1972): 27–66, and F. Richard Stephenson and Kevin K. C. Yau, "Far Eastern Observations of Halley's Comet, 240 BC to AD 1368," *Journal of the British Interplanetary Society* 38 (1985): 195–216.

3. For example, Chen Zungui, *Zhongguo tianwenxue shi* (History of Chinese astronomy) (Taipei: Mingwen Shuju, 1984–), vol. 2, and Yi Shitong, *Quantian xingtu: 2000.0* (All-sky star atlas for epoch 2000.0) (Beijing, 1984).

4. John Williams, *Observations of Comets from B.C. 611 to A.D. 1640* (London: Strangeways and Walden, 1871); Gustave Schlegel, *Uranographie chinoise; ou, Preuves directes que l'astronomie primitive est originaire de la Chine, et qu'elle a été empruntée par les anciens peuples occidentaux à la sphère chinoise*, 2 vols. (Leiden: E. J. Brill, 1875; reprinted Taipei: Chengwen Chubanshe, 1967); Alexander Wylie, *Chinese Researches* (Shanghai, 1897), pt. 3 (scientific), 110–39; P. Tsutsihashi and Stanislas Chevalier, "Catalogue d'étoiles observées à Pé-kin sous l'empereur K'ien-long (XVIII^e^ siècle)," *Annales de l'Observatoire Astronomique de Zô-sè (Chine)* 7 (1911): I-D105; and Ho Peng-yoke, trans. and annotator, *The Astronomical Chapters of the Chin Shu* (Paris: Mouton, 1966), 67 ff. and 263 ff.

5. Joseph Needham, *Science and Civilisation in China* (Cambridge: Cambridge University Press, 1954–), vol. 3, with Wang Ling, *Mathematics and the Sciences of the Heavens and the Earth* (1959). For more recent but briefer discussions, with an emphasis on Korean celestial cartography, see Sang-woon Jeon (Chŏn Sang'un), *Science and Technology in Korea: Traditional Instruments and Techniques* (Cambridge: MIT Press, 1974), esp. 22–33, and Joseph Needham et al., *The Hall of Heavenly Records: Korean Astronomical Instruments and Clocks, 1380–1780* (Cambridge: Cambridge University Press, 1986), esp. chap. 5.

6. Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo (Archaeological

Zhongguo hengxing guance shi (History of stellar observations in China) by Pan Nai contains an extensive discussion of the history of Chinese uranography.[7] This work also contains numerous illustrations, regrettably of mediocre quality: these are mainly of Chinese star maps and globes, but Japanese and Korean charts are also included. Both of these recent compilations are indispensable aids to the study of East Asian celestial cartography.

Independent Developments in Chinese Celestial Cartography

Early documentary evidence suggests that astronomy developed in ancient China independently from other civilizations. Preserved texts make no positive allusion to any interaction between China and other cultures until as late as about 130 B.C.[8] This lack is hardly surprising in view of the relative isolation of China. Suggestions of cultural exchanges between China and the West in remote antiquity have been made from time to time, but these are largely based on inference rather than on authentic records.[9]

No contacts of astronomical significance between China and India are recorded until the Tang dynasty (618–907).[10] By this period, however, the complex system of political astrology that had evolved in China through the centuries had long since been codified.[11] Despite the presence of Indian astronomers at the Tang court, there were no fundamental changes in the course of Chinese astronomy, and astrography in particular. Major star charts from China in the medieval period reveal negligible traces of Western innovations. Foreign influence was felt only in unofficial culture—for instance, in the Tang vogue of horoscope astrology.[12]

Arab astronomers were active in China from the Yuan dynasty (1279–1368) onward, and at the very beginning of the Ming (1368) an Islamic astronomical bureau was set up in the capital. However, only with the arrival of the Jesuit astronomers in China from the late sixteenth century onward do we find important improvements of foreign origin in mapping the night sky. Several Jesuits obtained high positions at the Chinese court, including the directorship of the imperial observatory itself. The Jesuit astronomers charted the stars with an accuracy hitherto unrivaled in China and, furthermore, introduced detailed knowledge of the far southern constellations, but there is little evidence that they tried to supplant the traditional Chinese representation of the night sky by the Occidental constellations. Only in the twentieth century did the Western tradition of astral cartography finally gain supremacy in China.

During the latter half of the first millennium, Chinese methods of astronomy and astrology—along with other aspects of culture—spread to Korea and Japan and afterward to Vietnam. In each of these countries celestial observations began to be made in the traditional Chinese style, and this pattern continued down to relatively modern times.[13] It is thus not surprising that the extant star maps from Korea and Japan (there appear to be no significant survivals from Vietnam, but see p. 504) clearly display Chinese influence and in general reveal little that is original. Korean star maps will be discussed toward the end of this chapter; star maps from Japan are the subject of chapter 14.

Research Institute, Chinese Academy of Social Science [Academia Sinica]), *Zhongguo gudai tianwen wenwu tuji* (Beijing: Wenwu Chubanshe, 1980).

7. Pan Nai, *Zhongguo hengxing guance shi* (Shanghai, 1989).

8. The Chinese envoy Zhang Qian reached as far west as Bactria in 128 B.C. A detailed account of his travels is given by Sima Qian in chapter 123 of the *Shi ji* (Records of the grand historian, completed ca. 91 B.C.). For an English translation of this narrative, see Friedrich Hirth, "The Story of Chang K'iên, China's Pioneer in Western Asia: Text and Translation of Chapter 123 of Ssï-ma Ts'iên's Shï-ki," *Journal of the American Oriental Society* 37 (1917): 89–152.

9. See, for example, Joseph Needham, *Science and Civilisation in China* (Cambridge: Cambridge University Press, 1954–), vol. 1, with Wang Ling, *Introductory Orientations* (1954), 150 ff.; Edwin G. Pulleyblank, "Chinese and Indo-Europeans," *Journal of the Royal Asiatic Society of Great Britain and Ireland*, 1966, 9–39. A case for the cultural isolation of ancient China is made by Michael A. N. Loewe in his introduction to A. F. P. Hulsewé, *China in Central Asia: The Early Stage, 125 B.C.–A.D. 23* (Leiden: E. J. Brill, 1979), 39 ff.

10. Yabuuchi Kiyoshi (Yabuuti Kiyosi), "Researches on the *Chiu-chih Li*—Indian Astronomy under the T'ang Dynasty," *Acta Asiatica* 36 (1979): 7–48, is useful on this topic.

11. The practice of astrology in China from at least the second century B.C. involved court astronomers' maintaining a regular watch of the day and night sky for portents such as eclipses, comets, and lunar and planetary conjunctions. These omens were interpreted according to a carefully prescribed set of rules, based largely on the star group in or near which the phenomenon was seen. For extensive examples of ancient Chinese portentology, see Ho, *Astronomical Chapters* (note 4).

12. A few rather crude medieval star maps of Chinese origin—for example, a chart painted on the ceiling of a twelfth-century tomb—are preserved that portray both the signs of the Western zodiac and East Asian star groups. Examples of horoscope astrology during the Tang dynasty are given by Edward H. Schafer, *Pacing the Void: T'ang Approaches to the Stars* (Berkeley and Los Angeles: University of California Press, 1977), 58 ff.

13. As in the case of China, the records of many of these observations are still preserved today. See for example, Seong-rae Park, "Portents and Neo-Confucian Politics in Korea, 1392–1519," *Journal of Social Sciences and Humanities* 49 (1979): 53–117; Kanda Shigeru, *Nihon tenmon shiryo* (Japanese astronomical records) (Tokyo, 1935); Ho Peng-yoke, "Natural Phenomena Recorded in the *Đai-Viêt su'-ky toan-thu'*, an Early Annamese Historical Source," *Journal of the American Oriental Society* 84 (1964): 127–49.

The Beginnings of Celestial Cartography in China

The origins of uranography in China are lost in antiquity. In attempting to trace the evolution of celestial mapping in ancient China, we are seriously hampered by the low survival rate of suitable documents. No star maps or catalogs earlier than the Former Han dynasty (206 B.C.–A.D. 8) are now extant. In fact, scarcely any Chinese texts on astronomy that were written before this period are currently known to exist; as a rule, only fragmentary quotations are preserved in later works. Hence, for the most ancient—and probably the most crucial—period of the development of astronomy in China, the researcher must rely almost entirely on whatever information can be gleaned from such diverse sources as oracle texts, almanacs, chronicles, and even poetic works. Although several star groups are mentioned in inscriptions dating from before 1000 B.C., the fact remains that texts originating earlier than about 100 B.C. preserve the names of no more than about thirty separate asterisms. Yet later writings assert that by roughly 300 B.C. the night sky had already been divided into nearly three hundred constellations.[14]

In the absence of surviving astral charts, extant catalogs can give a sound indication of the level mapping had attained at the period in question. The relation between cataloging and mapping stars is not well defined, however. An accurate star map will normally be based on a catalog, but sketch maps of constellations (as found in many tombs) can be made quite independently. Also, constellation lists that give only brief indications of relative positions of stars are often constructed for purely astrological purposes.

According to tradition, preserved in texts written many centuries after the events they purport to describe, astronomy was practiced in China almost from the dawn of civilization. Thus, writing about 91 B.C., the great historian and astronomer Sima Qian (ca. 145–ca. 85 B.C.) stated in his *Shi ji* (Records of the grand historian) that to his knowledge there had never been a time when the rulers of China failed to encourage observation of the heavens.[15] Sima Qian also listed some of the principal astronomers from earliest (legendary) times down to his own era. In the seventh century A.D., Li Chunfeng (602–70), author of the astronomical treatise incorporated in the *Jin shu* (History of the Jin), followed much the same tradition, emphasizing the importance assigned to astronomy in the time of the sage-rulers of old.[16]

The semilegendary *Shu jing* (Book of documents), containing some sections written during the Zhou dynasty (ca. 1027–256 B.C.), cites an interesting account in its "Yao dian" (Canon of Yao). This relates how in remote antiquity the sage-emperor Yao commanded the Xi and He brothers "in reverent accordance with the august heavens, to compute and delineate the sun, moon and stars . . . and so deliver respectfully the seasons to be observed by the people."[17] The "Yao dian" further relates that four stars (Niao, Huo, Xu, and Mao) were to be observed by astronomers situated at the extreme limits of the Chinese dominions in order to determine the seasons. Yet the whole account is so idealized that it appears to be no more than an imaginative tale with little or no factual basis.[18]

In practice, no direct attestation of astronomical activity in China is preserved before the Shang (ca. sixteenth to eleventh century B.C.),[19] and even this evidence is sparse. It is from this period (also known as the Yin dynasty) that the earliest written records survive. Before the Shang, Chinese history gives way to legend. For instance, the existence of the Xia dynasty, which according to traditional Chinese history immediately preceded the Shang, has yet to be adequately substantiated.[20] Astronomical data that purport to originate in the Xia, but that likely are much more recent, are contained in the *Xia xiaozheng* (Lesser calendar of the Xia). This work, which is essentially a farmers' calendar, notes how certain months were marked by the visibility of particular star groups.[21]

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14. See, for example, Fang Xuanling et al., *Jin shu* (History of the Jin, compiled 646–48), chap. 11; modern edition in 10 vols. (Beijing: Zhonghua Shuju, 1974). Further details are given below. "Asterism," a term of Greek origin (*asterismos*) implying a minor constellation, is often used to describe Chinese star groups.

15. This statement is recorded in the astronomical treatise (chap. 27) of the *Shi ji*. For a translation of Sima Qian's treatise, see Edouard Chavannes, trans., *Les mémoires historiques de Se-Ma Ts'ien*, 5 vols. (Paris: Leroux, 1895–1905), 3:339–412.

16. See the translation from chap. 11 of the *Jin shu* by Ho Peng-yoke, *Li, Qi and Shu: An Introduction to Science and Civilization in China* (Hong Kong: Hong Kong University Press, 1985), 115–16.

17. Translated by Ho, *Li, Qi and Shu*, 116–17 (note 16).

18. Much this same view is taken by Yabuuchi Kiyoshi, *Chūgoku no tenmon rekihō* (The history of astronomy and calendrical science in China) (Tokyo: Heibonsha, 1969; rev. ed. 1990), 267.

19. A chronological scheme showing the inclusive dates of the various Chinese dynasties is given above, table 2.1, p. 25. Most of these dates are precisely known, but the beginning and end of the Shang are still a matter for conjecture.

20. For comments regarding the status of the Xia, see, for example, Charles Patrick Fitzgerald, *China: A Short Cultural History*, 4th rev. ed. ([London]: Barrie and Jenkins, 1976), 26–28. Recently, various contributors to *Early China* 15 (1990): 87–133 have taken a rather conservative view of the Xia.

21. A translation of the *Xia xiaozheng* was made by William Edward Soothill, *The Hall of Light: A Study of Early Chinese Kingship* (London: Lutterworth Press, 1951), 237–42. Herbert Chatley, "The Date of the Hsia Calendar *Hsia Hsiao Chêng*," *Journal of the Royal Asiatic Society of Great Britain and Ireland*, 1938, 523–33, summarized the astronomical references in this work and investigated the visibility of the various asterisms it contains. He concluded that all the data in the

FIG. 13.1. SHANG ORACLE BONE WITH REFERENCE TO THE FIRE STAR (ANTARES). This inscribed ox bone, found near Anyang and dating from ca. 1300 B.C., contains one of the earliest allusions to a star in Chinese history. The star, named at the end of the central column of characters, is called Huo. (This is a negative of the rubbing.)
Size of the original: 14 × 4.5 cm. Photograph courtesy of F. Richard Stephenson.

Shang chronology is still by no means securely established; few datable texts are preserved from this early period. Original Shang records consist almost entirely of "oracle bones," divination texts inscribed on turtle shells and animal bones using a primitive form of Chinese script.[22] So far it has been possible to obtain only tantalizing glimpses of Shang astronomy. Celestial observations recorded on the oracle bones are rare, as might be expected of texts of this nature, and the names of only a few constellations are mentioned.

The oracle bone inscriptions have long been known to contain allusions to eclipses, and in the past few decades there have been several attempts to deduce the dates of these observations using astronomical calculations.[23] Recently, extensive searches have been made for other astronomical records on the Shang oracle bones.[24] Apart from eclipses, occasional references to the planet Jupiter, comets (all undatable), and certain star groups were noted. No planet other than Jupiter has yet been identified on Shang inscriptions. Constellations are almost exclusively mentioned in the context of sacrifice; evidently it was the custom to make regular offerings to them (and also to Jupiter), as the following example illustrates: "There was a divination on day *jiyou*. In the night of day *geng (-xu)*, a sacrifice was made to Dou (the Dipper). There was a divination on day *geng (-xu)*. In the night of *xin (-hai)*, a sacrifice was (again) made to Dou."[25]

Xia xiaozheng are quite consistent with a date of compilation about 350 B.C. This is more than a thousand years after the Xia is supposed to have come to an end.

22. Valuable discussions of oracle bone inscriptions and Shang divination are given by David N. Keightley, *Sources of Shang History: The Oracle-Bone Inscriptions of Bronze Age China* (Berkeley and Los Angeles: University of California Press, 1978), 3–27, and Hung-hsiang Chou, "Chinese Oracle Bones," *Scientific American* 240 (April 1979): 134–49. The relics, first discovered near Anyang at the end of the nineteenth century, probably date from the latter part of the Shang, between about 1350 and 1050 B.C. So far about 160,000 texts—mostly no more than fragments incised with a few characters—have been cataloged.

23. See, for example, Dong Zuobin (Tung Tso-pin), *Yin lipu* (On the calendar of the Yin dynasty) (Lizhuang, Szechuan: Academia Sinica, 1945), pt. 2, 1–37; Homer H. Dubs, "The Date of the Shang Period," *T'oung Pao* 40 (1951): 322–35; Zhang Peiyu, Xu Zhentao, and Lu Yang, "Zhongguo zui zao qi di rishi jilu he gongyuanqian shisi zhi gongyuanqian shiyi shiji rishi biao" (China's earliest records of solar eclipses and a solar eclipse table for the fourteenth to the eleventh century B.C.), *Nanjing Daxue Xuebao* (1982): 371–409, esp. 381–84.

24. The only detailed account in a Western language is by Xu Zhentao, Kevin K. C. Yau, and F. Richard Stephenson, "Astronomical Records on the Shang Dynasty Oracle Bones," *Archaeoastronomy* 14, suppl. to *Journal for the History of Astronomy* 20 (1989): S61–S72. A prior investigation, published in Chinese, was made by Wen Shaofeng and Yuan Tingdeng, *Yinxu buci yanjiu: Kexue jishu pian* (Studies on Yin oracle bone writings: Science and technology volume) (Chengdu: Sichuan Shehui Kexue Chubanshe, 1983), 1–66.

25. Xu, Yau, and Stephenson, "Astronomical Records," 568 (note 24); many of my subsequent remarks on Shang constellations are also derived from this source.

In the example above, *jiyou*, *gengxu*, and *xinhai* were consecutive days, the forty-sixth, forty-seventh, and forty-eighth days of a sixty-day cycle. This same cycle has continued in use, probably without interruption, until the present.

Several further references to the star group Dou are preserved on other oracle bone fragments. This asterism was probably identical with the Big Dipper or Plow in Ursa Major, whose shape is so characteristic that it probably was one of the earliest constellations to be recognized. Dou is also mentioned in texts of the subsequent Zhou dynasty, and here its identity with the Big Dipper is readily apparent (see below). Two additional stars or star groups that are referred to on the oracle bones are Huo (Fire) (see fig. 13.1) and Xin (Heart). These names, which probably relate respectively to the bright red star Antares and a group of three stars centered on Antares, remain in use in later Chinese history. Other Shang allusions to asterisms occur relatively rarely, and the identity of the constituent stars is more problematic; in particular, none of the inscriptions give any indication of celestial location.

Pending further investigation of Shang texts, it is impossible to determine whether the people of the time took notice only of the more prominent features of the night sky or whether they already recognized a variety of constellations. Although very few asterisms have so far been identified on Shang inscriptions, these records are of some significance in the history of celestial cartography; they contain the earliest known Chinese references to the grouping of stars into constellations that are in any way reliable. It is also worth emphasizing that the allusions to asterisms found on the oracle bones—as well as Shang references to the planet Jupiter—are among the oldest that survive from any civilization.

The Constellations as Envisaged during the Western and Eastern Zhou Dynasties and the Chunqiu Period (ca. 1027–468 B.C.)

Compared with those from the Shang, relatively few original documents survive from its successor, the Zhou dynasty. Nevertheless, late copies of several Zhou texts are available, some having been printed and reprinted many times. Important astronomical references are found in a few writings that either originated at this time or contain much contemporary material. These works include the *Chunqiu*, *Zuozhuan*, and *Shi jing*.

The *Chunqiu* (Spring and autumn [annals]) is a chronicle of Lu, one of the early feudal states of China, during the period from 722 to 480 B.C.[26] This chronicle, which according to tradition was compiled by Confucius, records many eclipses and also a few comets and meteors.[27] By the Chunqiu period, the rulers of individual states employed astronomers to keep a watch for celestial omens and also to maintain a reliable calendar. The names of some of these astronomers are still preserved.[28] Nevertheless, only a single star group is noted in the *Chunqiu*. In 613 B.C. it is recorded that a comet entered the asterism Beidou (Northern Dipper),[29] which is identifiable with the Big Dipper.

In 525 B.C. another comet was reported, this time at Dachen. Later known as Dahuo, Dachen was one of the *ci*, or "Jupiter stations." Here we have one of the earliest references in Chinese history to these twelve equal divisions of the sky (and later of the celestial equator) based on the motion of Jupiter, or rather its supposed invisible counterrotating correlative planet Taisu.[30] Since Jupiter completes a full circuit of the sky in almost twelve years, the sun in its annual course would spend a month in each division. Apart from the number of stations, the *ci* (which were still important in Chinese astrology in relatively recent times) had nothing in common with the signs of the Western zodiac. The latter divisions are based on the ecliptic rather than the celestial equator. In Chinese astronomy and astrology the zodiac has never held a special place except in popular thinking.

In the *Zuozhuan* (Zuo's tradition [of interpreting the *Chunqiu*]), an ancient enlargement of the spring and autumn annals, a number of scattered references to star groups occur, notably Huo (the Fire Star or Antares).[31]

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26. Similar chronicles were kept in other feudal states, but most were presumably destroyed at the Burning of the Books in the Qin dynasty (221–207 B.C.). See Burton Watson, *Early Chinese Literature* (New York: Columbia University Press, 1962), 37.

27. That it was compiled by Confucius is asserted by Mencius, see *Mengzi*, bk. 3, pt. 2, chap. 9; modern edition with translation by James Legge, ed. and trans., *The Four Books* (1923; reprinted New York: Paragon, 1966), 676–77. For a recent discussion of the astronomical records in the *Chunqui*, see F. Richard Stephenson and Kevin K. C. Yau, "Astronomical Records in the *Ch'un-ch'iu* Chronicle," *Journal for the History of Astronomy* 23 (1992): 31–51.

28. For example, in chap. 27 of the *Shi ji* (see the modern edition in 10 vols. [Beijing: Zhonghua Shuju, 1977]) and chap. 11 of the *Jin shu* (note 14). Ho, *Astronomical Chapters*, 46–48 (note 4), gives some useful comments on individual astronomers of the period based on biographical details in the *Shi ji*.

29. At this early period, the more common name is simply Dou. Later texts also frequently allude to Nandou (Southern Dipper), a group of six stars in Sagittarius resembling Beidou.

30. For further details see, for example, Liu Tan, *Zhongguo gudai zhi xingsui jinian* (Ancient Chinese Jupiter-cycle calendar) (Beijing: Kexue Chubanshe, 1957), and Needham, *Science and Civilisation*, 3:402–4 (note 5).

31. Translations of the *Chunqiu* together with the *Zuozhuan* have been made by James Legge, *The Chinese Classics*, 5 vols. (Hong Kong: Hong Kong University Press, 1960 [reprint of last editions, 1893–95]), vol. 5, and by Séraphin Couvreur, trans., *Tch'ouen Ts'ou et Tso Tchouan*, 3 vols. (Hochienfu: Mission Press, 1914).

Several of the *ci* are also alluded to. The *Zuozhuan* covers much the same period as the *Chunqiu*, but its date of compilation has been much disputed. It was anciently attributed to Zuo Qiuming, a contemporary of Confucius,[32] but there is now general agreement that the bulk of the book was written about 300 B.C., with some later additions.[33] The *Zuozhuan* is remarkable for the large amount of extended narrative material it contains; this contrasts with the terse style of the *Chunqiu* itself. Some of this material may be legendary, but much is probably factual, based on sources that have long since disappeared. Certain of the reports in the *Zuozhuan* may be corroborated not only by other written sources but also by archaeological evidence.[34]

For dates before about 600 B.C., stars are usually referred to in the *Zuozhuan* as seasonal markers, but later we find evidence of the development of astrological prediction, based largely on previously recorded coincidences between celestial and terrestrial events. Such an example occurred in 532 B.C.:

> This spring, in the king's first month, a (strange) star appeared in (the constellation) Wu-nu. Pei Zhao of Qing said to Zichan, "In the 7th month, on [day] *wuzi*, the ruler of Jin will die. . . . It was on [day] *wuzi* that duke Feng (anciently) ascended on high, when a (strange) star appeared in this same place. Thus it is that I make this observation."
>
> On [day] *wuzi*, duke Ping of Jin died.[35]

In the various early folk songs assembled in the *Shi jing* (Book of odes) there are several references to star groups.[36] The *Shi jing* was probably compiled about 600 B.C., although many of the odes may date from several centuries earlier.[37] Only about ten separate asterisms are alluded to, but since these are mentioned almost at random, it is plausible that many more star groups were recognized at this early period. Most of the constellation names are identical with those used in later times, although there are also one or two archaic renderings.

The *Shi jing* contains the earliest recorded allusions in Chinese history to the Milky Way (Tianhanhe, or Celestial Han River). An extract from one of these odes seems worth quoting here, since it mentions both the Milky Way and several discrete asterisms:

> In the heavens there is the (celestial) Han (the Milky Way), it looks down and is bright. . . . Brilliant is the Draught Ox, but one does not yoke it to any carriage; in the east there is the Opener of Light (Lucifer); in the west there is the Long Continuer (Hesperus). . . . In the south there is the Winnowing Basket, but one cannot winnow with it, in the north there is the Ladle, but one cannot ladle wine or congee with it . . . in the north there is the Ladle, it raises its western handle.[38]

Here the Draught Ox is the asterism Niu in Capricorn, and the Winnowing Basket is the star group Ji in Sagittarius. As noted above, the Ladle (Dou) refers to the Big Dipper. The apparent rotation of the "handle" of this constellation around the north celestial pole formed a convenient hourly and seasonal marker to many early civilizations—for example, Sumerian, Indian, and Egyptian.[39] In ancient times the Big Dipper was much closer to the celestial pole than at present owing to the precession of the equinoxes.[40] Hence its rotation about the pole would be particularly obvious.

The concept of a pole star seems to date at least to the Chunqiu age. Thus in the *Lun yu* (Analects [of Confucius]), a work that dates from the fifth or fourth century B.C., it is recorded that "the Master said, 'He who exercises government by means of his virtues may be compared to the north polar star, which keeps its place and all the stars turn towards it.' "[41] At the time, the nearest bright star to the north celestial pole would be β UMi (Kochab), some seven degrees away.[42]

It is noteworthy that of the asterisms mentioned in the *Shi jing*, most (including Niu and Ji cited in the quotation above) are identifiable with what in more recent texts are

32. See, for example, the *Shi ji*, chap. 14 (note 28).

33. Valuable historical comments are provided by Watson, *Early Chinese Literature*, 40–66 (note 26), and Timoteus Pokora, "Pre-Han Literature," in *Essays on the Sources for Chinese History*, ed. Donald D. Leslie, Colin Mackerras, and Wang Gungwu (Canberra: Australian National University Press, 1973), 23–35, who also give important surveys of other pre-Han literature.

34. See, for example, Roland Felber, "Neue Möglichkeiten und Kriterien für die Bestimmung der Authentizität des Zuo-Zhuan," *Archiv Orientální* 34 (1966): 80–91.

35. Translated by Legge, *Chinese Classics*, 5:628–29 (note 31). In citing this and other translations and quotations throughout this chapter, I have substituted pinyin romanization.

36. There are fine English translations of the poems in the *Shi jing* by Arthur Waley, trans., *The Book of Songs* (London: Allen and Unwin, 1937), and Bernhard Karlgren, ed. and trans., *The Book of Odes* (Stockholm: Museum of Far Eastern Antiquities, 1950; reprinted 1974).

37. Useful comments on the date of the *Shi jing* are given by Watson, *Early Chinese Literature*, 202–30 (note 26).

38. This translation, part of Ode 203, is by Karlgren, *Book of Odes*, 155 (note 36).

39. A discussion of the importance of the Dipper to early civilizations is given by Donald J. Harper, "The Han Cosmic Board (*Shih* 式)," *Early China* 4 (1978): 1–10.

40. Precession is largely produced by solar and lunar torques acting on the rotating earth. These torques cause the earth's axis of rotation to describe a circle of approximately twenty-four degrees radius over a period of some 26,000 years. A gradual displacement of the celestial poles relative to the stars results.

41. *Lun yu*, bk. 2, chap. 1, translated by Legge, *Chinese Classics*, 1:145 (note 31).

42. This star appears to have remained the pole marker until the Later Han, by which time, owing to the effect of precession, its distance from the celestial pole had increased to nearly ten degrees (see below). About 500 B.C., Polaris (α UMi) was as much as fifteen degrees from the north celestial pole.

TABLE 13.1 The Twenty-eight Lunar Lodges

Number	Name (Translation)	Determinative Star	Computed Angular Extent (Han Dynasty)
1	Jue (Horn)	α Vir	12°
2	Kang (Neck)	κ Vir	9°
3	Di (Base)	α Lib	15°
4	Fang (Chamber)	π Sco	5°
5	Xin (Heart)	σ Sco	5°
6	Wei (Tail)	μ Sco	19°
7	Ji (Basket)	γ Sgr	11°
8	Nandou (Southern Dipper)	φ Sgr	27°
9	Niu (Ox)	β Cap	8°
10	Xunü (Maid)	ε Aqr	12°
11	Xu (Emptiness)	β Aqr	10°
12	Wei (Rooftop)	α Aqr	17°
13	Yingshi (Encampment)	α Peg	17°
14	Dongbi (Eastern Wall)	γ Peg	9°
15	Kui (Stride)	ζ And	16°
16	Lou (Harvester)	β Ari	11°
17	Wei (Stomach)	35 Ari	15°
18	Mao (Mane?)	17 Tau	11°
19	Bi (Net)	ε Tau	18°
20	Zuixi (Turtle Beak)	φ' Ori	1°
21	Shen (Triad)	δ Ori	8°
22	Dongjing (Eastern Well)	μ Gem	33°
23	Yugui (Ghost Vehicle)	θ Cnc	4°
24	Liu (Willow)	δ Hya	15°
25	Qixing (Seven Stars)	α Hya	7°
26	Zhang (Extended Net)	υ Hya	17°
27	Yi (Wings)	α Crt	18°
28	Zhen (Axletree)	γ Crv	17°

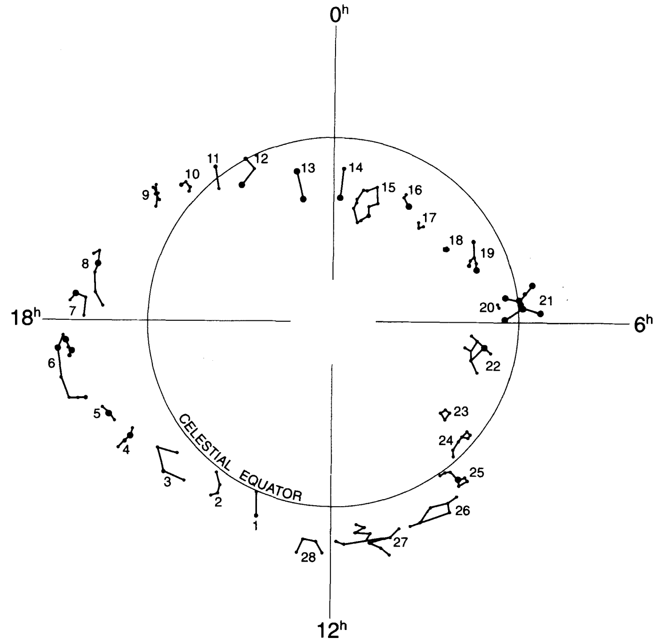


FIG. 13.2. THE UNEVEN DISTRIBUTION OF THE LUNAR LODGES. The diagram clearly shows this concept and also indicates stellar magnitude by size of symbol. Although the *xiu* were in general closer to the celestial equator in ancient times, the correspondence was never good. See also table 13.1, which lists the names, determinative stars, and computed angular extent of the lunar lodges.

termed *xiu* (lunar lodges). These are a series of twenty-eight constellations encircling the sky in the vicinity of the celestial equator. (The expression *xiu* is a derivative of *su*, "to stay the night.") The names of several lunar lodges have also been noted on certain bronze vessels that date from much the same period as many of the folk songs in the *Shi jing*.[43] This suggests that by fairly early in the first millennium B.C. at least some of the *xiu* had already acquired special significance. Nevertheless, the notion of the lunar lodges as a discrete entity cannot be firmly established by documentary evidence until as late as the fifth century B.C.[44]

From at least the Former Han dynasty onward, the lunar lodges were of prime importance in uranography. They defined the celestial coordinates of other star groups—as well as specifying the locations of the sun, moon, and planets—and were also regarded as of great astrological significance. Owing to the sparseness of the available evidence, however, the evolution of the concept of the *xiu* from rough celestial markers to the basis of

43. See Needham, *Science and Civilisation*, 3:248 note d (note 5). In this chapter the word "lodge" has been used (rather than "mansion") in translating *xiu*; lodge has been substituted for mansion in quotations as well.

44. A chest bearing the names of all twenty-eight lunar lodges in order dating from about 433 B.C. was discovered in 1978; see pp. 519–20 for further details.

a developed coordinate system cannot be traced in any detail.

Table 13.1 gives a standardized list of the twenty-eight lunar lodges as found in texts from the third century B.C. onward. Subsequently there were only minor variations in the designations of individual lodges. In this table the *xiu* are numbered in their traditional order, commencing with Jue; translations of individual names are appended. A few names among the first seven *xiu* relate to various features of the celestial dragon (see below), but the other designations seem little more than a random assemblage and in general are much more mundane than those of the Western zodiacal signs.

Astronomical calculations involving the precession of the equinoxes yield an extremely ancient date for the origin of the lunar lodges. The *xiu* lie fairly close to a great circle that today is by no means coincident with the celestial equator (fig. 13.2). By applying precession, one can readily show that in ancient times the circle of the lodges was a better approximation to the celestial equator than at present. Modern studies based on this and similar ideas have suggested the middle of the third millennium B.C. as the date when the *xiu* were first conceived,[45] but there is no evidence of an advanced culture in China at such a remote period—at least a millennium before the earliest written records from this part of the world.

At present it is not possible to ascertain whether only a few relatively well-defined asterisms were recognized in the early Zhou and Chunqiu periods or whether—as seems more likely—the stars had already been grouped into many of the patterns familiar in more recent times. Certainly there is no hint of the existence of star maps in the Zhou dynasty. The astronomers of the period seem to have possessed few instruments. For example, only the gnomon is alluded to in the *Zuozhuan*.[46] Not until the Zhanguo (Warring States) period do we find the first suggestions of systematic division of the night sky, and even then information is accessible mainly in secondary sources of questionable reliability.

Celestial Cartography in the Zhanguo Period (403–221 B.C.)

The Zhanguo period, which followed the Chunqiu era, was a time of marked philosophical speculation.[47] It is thus disappointing that little definite information can be established with regard to the development of astronomy during the Zhanguo; in particular, no star maps that date from these times are known to survive. Texts written many centuries later trace the origins of serious mapping of the night sky in China to this period.[48] There is a persistent tradition that Zhanguo mapping had an important influence on future uranography. For example, chapter 11 of the *Jin shu*, compiled about A.D. 635, contains the following statement in a section titled "Tianwen jingxing" (The stars of the heavens):

> During the time of Emperor Wudi (reign [A.D.] 265–90), Chen Zhuo the Astronomer Royal combined together the astronomical charts made by the three (ancient) schools of Gan (De), Shi (Shen) and Wu Xian, giving a total number of 283 star groups and 1,464 stars in (his) records. A general outline of the more significant ones is now given to complete the (following) section on the stars.[49]

The *Jin shu* proceeds to give a descriptive list of 240 constellations in which measurements are lacking; the main emphasis is astrological. The account above is elaborated in the astronomical treatise (chap. 19) of the *Sui shu* (History of the Sui, compiled 629–56 by Wei Zheng et al.)—much the same time as the *Jin shu*—while additional details are found in an astrological manuscript of the early seventh century A.D. that Paul Pelliot recovered from Dunhuang in 1908.[50] Further reference to these sources will be made below.

It was long supposed that a portion of a star catalog compiled by Shi Shen, who was an astronomer of the Wei state during the Zhanguo, was preserved in the much more recent *Kaiyuan zhanjing* (Kaiyuan treatise on astrology), compiled about 730 by the Indian astronomer Gautama Siddhārtha (Qutan Xida).[51] In a section titled *Xingjing* (Star classic), the *Kaiyuan zhanjing* lists the north polar distances and other details for the key stars of the

45. See, for example, Chu K'o-chên, "The Origin of the Twenty-eight Lunar Mansions," *Actes du VIII^e Congrès International d'Histoire des Sciences (1956)* (Florence: Gruppo Italiano di Storia delle Scienze, 1958), 1:364–72; David S. Nivison, "The Origin of the Chinese Lunar Lodge System," in *World Archaeoastronomy*, ed. A. F. Aveni (Cambridge: Cambridge University Press, 1989), 203–18.

46. A solstitial observation made in 655 B.C. is recorded in the *Zuozhuan*; see Legge, *Chinese Classics*, 5:142 and 144 (note 31).

47. For example, the great philosophers Mencius (372–289 B.C.), Mo Zi (470–391 B.C.?), and Han Feizi (d. 233 B.C.) all lived during the Zhanguo.

48. There are no such assertions in preserved writings dating from the centuries immediately following the Zhanguo.

49. Translated by Ho, *Astronomical Chapters*, 67 (note 4). A few quotations ascribed to Shi Shen and Gan De are contained in the astronomical treatise of the *Han shu* (History of the Former Han), compiled by Ban Gu about the first century, but the main source of alleged extracts from the works of Gan De, Shi Shen, and Wu Xian is a late treatise, the *Kaiyuan zhanjing*. From a study of these fragments, Maspero concluded that all lived sometime between about 350 and 250 B.C.; see Henri Maspero, "L'astronomie chinoise avant les Han," *T'oung Pao* 26 (1929): 267–356, esp. 269–70. In particular, Wu Xian was probably a pseudonym; the original Wu Xian was reputed to be an astronomer of the Shang dynasty (*Shi ji*, chap. 27 [note 28]).

50. Maspero, "L'astronomie chinoise," 272 and 319 (note 49).

51. See, for example, Needham, *Science and Civilisation*, 3:197 and 266–68 (note 5). (Gautama held the position of astronomer royal in China.)

twenty-eight lunar lodges and also for reference stars in ninety-two other groups—about half of the visible sky.[52] Early histories such as the *Shi ji* and the *Hou Han shu* (History of the Later Han, compiled fifth century A.D. by Fan Ye) attribute a work bearing the title *Xingjing* to Shi Shen.[53]

Several years ago, Maeyama made a detailed investigation of the stellar positional measurements in the *Xingjing* section of the *Kaiyuan zhanjing*.[54] Applying precession, he was able to deduce a date within a few decades either side of 70 B.C., and thus long after the Zhanguo. Independent research by Yabuuchi reached much the same conclusion.[55] This date is well into the Former Han and about half a century after Hipparchus produced his famous star catalog. Hence the *Xingjing* as preserved today cannot be the same as the work of that name attributed to Shi Shen. Maeyama emphatically remarks, "Thus, a widely accepted assumption, that the first systematic measurements in equatorial coordinates covering 120 constellations should originally be ascribed to Shi Shen (350 B.C.), has now turned out to be a mere fiction."[56]

It is, of course, arguable that the measurements reported in the existing *Xingjing* represent revisions of more ancient observations that no longer survive. Even if this were the case, however, the form the original data took cannot be established. Discussion of the content of the *Xingjing* will be continued below in the section devoted to the Qin and Han dynasties. Because of the lack of suitable historical records, we cannot adequately assess the contribution to astronomy and, in particular, celestial cartography made during the Zhanguo. Nevertheless, we may conclude that evidence for detailed mapping of the night sky by Shi Shen and his presumed contemporaries Gan De and Wu Xian rests on late traditions rather than on more tangible evidence.

It has long been known that an almost complete list of the names of the lunar lodges is preserved in the *Yueling* (Monthly observances), an almanac that may have been composed during the Zhanguo.[57] In this work, which is concerned with agriculture, court ceremony, and so forth, the passing months are marked by the sun's position in various constellations and the culmination of certain star groups at dawn and dusk.

In 1978, archaeologists working in Hubei Province made a discovery that shed new light on the history of the lunar lodges. This was a lacquer chest, unearthed from the tomb of Yi, a marquess of the state of Zeng, who died about 433 B.C.[58] On the lid of the chest are inscribed in a roughly circular pattern the names of twenty-eight constellations (fig. 13.3). With only a few exceptions, these ideographs—which are artistically written in a style typical of the time—are identifiable in terms of the names of the lunar lodges as found in later texts and are cited in the usual order.[59] The various characters surround a much larger ideograph denoting Dou (the Dipper) and are inserted between representations of a tiger and a dragon. This inscription provides the earliest documentary evidence for the existence of twenty-eight lunar lodges. Before its discovery, the oldest known *complete* list of the *xiu* dated from approximately two centuries later.

The asymmetrical configuration of the characters denoting the lunar lodges on the lid of the chest is intriguing. It seems likely that the illustrations of the dragon and tiger and the large character Dou were executed first and the names of the *xiu* were inserted in the remaining space afterward.[60] There does not appear to be any deliberate attempt to portray the irregular spatial distribution of the *xiu* (fig. 13.2 above). Presumably the animals were intended to represent the Azure Dragon and White Tiger—two of the five palaces (*gong*) into which the night sky is known to have been divided at least from the

52. *Kaiyuan zhanjing*, chaps. 60–68 (there is an edition published in Beijing, 1786); the *Xingjing* is also copied in the Daozang (Daoist canon), in sec. 284 titled *Tongzhan daxiangli xingjing* (The great firmament star manual common to astrology).

53. For example, *Shi ji*, chap. 27 (note 28), and *Hou Han shu*, chap. 12; see the modern edition in 12 vols. (Beijing: Zhonghua Shuju, 1965–73).

54. Yasukatsu Maeyama, "The Oldest Star Catalogue of China, Shih Shen's Hsing Ching," in *Prismata: Naturwissenschaftsgeschichtliche Studien*, ed. Yasukatsu Maeyama and W. G. Salzer (Wiesbaden: Franz Steiner, 1979), 211–45.

55. Yabuuchi Kiyoshi, "*Sekishi Seikyo* no kansoku nendai" (The observational date of the *Shi Shen Xingjing*), in *Explorations in the History of Science and Technology in China*, ed. Li Guohao et al. (Shanghai: Shanghai Chinese Classics Publishing House, 1982), 133–41.

56. Maeyama, "Oldest Star Catalogue," 212 (note 54).

57. The *Yueling* has been translated by Sêraphin Couvreur, ed. and trans., *Li Ki; ou, Mémoires sur les bienséances et les cérémonies*, 2d ed., 2 vols. (Paris: Cathasia, 1913), vol. 1, chap. 4, 330–410. The work was attributed to Lü Buwei (d. 235 B.C.) by several Han critics, but the precise date of composition has been much disputed. Although in the first half of the present century some scholars favored compilation of the *Yueling* during the Chunqiu period, such an early date is not in keeping with the highly formalized and structured style of the almanac. For details, see Chūryō Nōda, *An Inquiry concerning the Astronomical Writings Contained in the Li-chi Yüeh-ling* (Kyōto: Kyōto Institute, Academy of Oriental Culture, 1938), 2. Based on astronomical computations, Nōda derived a date for the *Yueling* within about a century of 620 B.C., though the reliability of this date depends on the validity of his interpretation.

58. This chest is now in the Hubei Provincial Museum, Wuhan. For details see Wang Jianmin, Liang Zhu, and Wang Shengli, "Zeng Houyi mu chutu di ershiba xiu qinglong baihu tuxiang" (The twenty-eight lunar lodges and paintings of the Green Dragon and the White Tiger, from the tomb of Zeng Houyi), *Wenwu*, 1979, no. 7:40–45.

59. For several of the names, phonetic equivalents are used.

60. This was first suggested by Wang, Liang, and Wang, "Zeng Houyi" (note 58).

FIG. 13.3. LID OF A CHEST GIVING NAMES OF TWENTY-EIGHT LUNAR LODGES FROM A 433 B.C. TOMB. Names of individual lunar lodges, most of them identifiable with present-day names, are inscribed in a ring around the large character Dou (the Dipper). This chest, discovered in 1978 during excavations of the tomb of the marquess Yi, provides the earliest known list of all twenty-eight lunar lodges.
Size of the original: 82.8 × 47.0 × 19.8 cm. By permission of Hubei Provincial Museum, Wuhan.

Former Han dynasty.[61] As depicted on the chest lid, however, the orientation of the lunar lodges relative to the two animals is highly erroneous (roughly 180 degrees out of phase).

The Qin and Han Dynasties (221 B.C.–A.D. 220)

Present knowledge of Qin astronomy is still very incomplete, as is that for the Zhanguo and earlier periods. Nevertheless, the importance attached to stargazing in this short-lived dynasty (221–207 B.C.) can be judged from the large number of astronomers (more than three hundred) said to be in the service of the ruler.[62] Future excavations of the tomb of the first emperor Qin Shihuang—situated at Lintong near Xi'an—may possibly yield valuable information on Qin celestial cartography. To date, only an annex of the mausoleum has been examined, revealing the now world famous "terra-cotta army." The sepulcher itself has still to be excavated. Sima Qian gives the following account of the interior of this mausoleum, which was sealed in 210 B.C.:

> Liquid mercury was used to simulate the flow of the many rivers, (Chiang) Jiang, (Huang) He and the great sea. Machines were used to circulate (the mercury) and make it flow. Above, astronomical charts (tianwen) were drawn; below geographical maps were depicted.[63]

These "astronomical charts" presumably included representations of the constellations. As recent discoveries have emphasized (see below), the practice of painting star maps on the ceilings of Chinese tombs seems to have been fairly common from the Han dynasty onward.

A compendium of natural philosophy compiled in the state of Qin not long before China was unified, the *Lüshi*

61. The other three celestial palaces were named Red Bird, Dark Warrior, and Forbidden Purple (see below).

62. *Shi ji*, chap. 6 (note 28).

63. *Shi ji*, chap. 6; translation from F. Richard Stephenson and C. B. F. Walker, eds., *Halley's Comet in History* (London: British Museum Publications, 1985), 45.

Chunqiu (Master Lü's Spring and autumn [annals]), cites all twenty-eight lunar lodges in order. Until the discovery of the fifth century B.C. chest in the tomb of the marquess Yi, this was the earliest known complete list of the *xiu*. The *Lüshi Chunqiu* was compiled about the middle of the third century B.C. by a team of scholars gathered together by the prime minister Lü Buwei.[64] Names of the lodges, which are cited in a philosophical context, are essentially identical with those in table 13.1.

Archaeological excavations at Mawangdui (Hunan Province) in 1973 provided new information on astronomy during the Qin and also the early Han.[65] In that year many manuscripts were recovered from a tomb, along with an inscription giving the precise date of interment, which corresponds to 168 B.C. One of these texts, written on silk, gives the earliest reliable indication of the use of the lunar lodges to mark the positions of the planets.[66] This manuscript, now known as the *Wuxingzhan* (Prognostications from the five planets), details, among other matters, the various *xiu* in which the planet Venus rose and set between 246 and 177 B.C.[67] Such information had previously been found only in texts dating from about 100 B.C. onward—for example, in the astronomical treatise of the *Shi ji*—though the *Kaiyuan zhanjing* attributes similar data to Shi Shen and Gan De.

Han records reveal a firm belief in the correspondence between celestial and terrestrial events. An astronomer royal (*taishi ling*, literally prefect of the grand clerks) was appointed to take charge of astronomy, astrology, and the daily records of the empire. His duties were to record "any anomalous happenings in nature . . . , [which] were construed as signs of warnings by heaven toward the misbehavior or misgovernment of the ruler of man."[68] The practice of astronomy was largely centralized at the capital in the Han and all later dynasties, and the various instruments used by the official observers were closely guarded to prevent inspection by the general public. As a result, practically all of the major star maps and catalogs throughout Chinese history were produced by the imperial astronomers.

Although the oldest extant astral charts in China date from the Han, survivals are fairly rare, and only a few constellations are depicted. However, there is ample evidence that Han uranography reached a high level of attainment. Histories of the period give brief descriptions of several star maps and also a celestial globe, and two contemporary stellar catalogs have come down to us. By the Former Han we find the first definite evidence of a system of celestial coordinates in China. In this scheme, which continued in use until the present century, the lunar lodges played a key role. The choice of spherical coordinates is consistent with the development of the *huntian* (enveloping heaven) theory, the concept of a spherical heaven, by at least the Former Han; otherwise this theory is not encountered until the Later Han (25–220).[69]

Star charts appear to have been common during the Han, especially in the later phase of this dynasty. Needham has drawn attention to several contemporary references to such artifacts. For example, the bibliographical section of the *Han shu* lists a work entitled *Yueling botu* (Silken map of the path of the moon), which Geng Shouchang presented to the emperor in 52 B.C., and the biography of Wang Mang (45 B.C.–A.D. 23), in chapter 99 of the *Han shu*, mentions a *zigetu* (chart of the Purple Palace).[70] Nothing else is known about these maps. An interesting discussion among astronomers in A.D. 92 is reported in *Xu Han shu* (Supplement to the Han history). Here it was said that star maps always have methods of graduation (i.e., coordinates),[71] suggesting that by this period such maps were fairly numerous.

The numbers of asterisms and stars noted in Han texts bear no relation to the figures that were later attributed to Zhanguo astronomers such as Shi Shen. Thus, in the astrological treatise ("Tianwen zhi") that forms chapter 26 of the *Han shu*, composed toward the end of the first century A.D. by Ma Xu, the following details are given:

> In the astronomical charts there can be found 118 groups of stars that can be identified inside (i.e. north of) and outside (i.e. south of) the (equatorial belt of

64. Lü Buwei was also credited by Han critics with authorship of the *Yueling* (note 57 above). The first twelve chapters of the *Lüshi Chunqui* are practically identical with the *Yueling*.

65. For brief details of the Mawangdui discoveries, see Michael A. N. Loewe, "Manuscripts Found Recently in China: A Preliminary Survey," *T'oung Pao* 63 (1977): 99–136, and idem, *Ways to Paradise: The Chinese Quest for Immortality* (London: George Allen and Unwin, 1979), 12 ff.

66. Another silk manuscript discovered in this tomb has attracted widespread attention because of the variety of cometary tails it depicts. See Xi Zezong, "The Cometary Atlas in the Silk Book of the Han Tomb at Mawangdui," *Chinese Astronomy and Astrophysics* 8 (1984): 1–7, and Michael A. N. Loewe, "The Han View of Comets," *Bulletin of the Museum of Far Eastern Antiquities* 52 (1980): 1–31.

67. For the text of this manuscript, see Mawangdui Han Mu Boshu Zhengli Xiaozu (Study Group on the Han Silk Manuscripts from Mawangdui), " 'Wuxing zhan' fubiao shiwen" (Explanatory table for "Prognostication from the Five Planets"), *Wenwu*, 1974, no. 11:37–39. The planet Venus repeats its pattern of visibility at eight-year intervals.

68. This quotation is taken from Wang Yü-ch'üan, "An Outline of the Central Government of the Former Han Dynasty," *Harvard Journal of Asiatic Studies* 12 (1949): 134–87, esp. 165. For a recent detailed study of Han portents, see Hans Bielenstein, "Han Portents and Prognostications," *Bulletin of the Museum of Far Eastern Antiquities* 56 (1984): 97–112.

69. Maeyama Yasukatsu, "On the Astronomical Data of Ancient China (ca. −100 +200): A Numerical Analysis (Part 1)," *Archives Internationales d'Histoire des Sciences* 25 (1975): 247–76, esp. 248.

70. Needham, *Science and Civilisation*, 3:276 (note 5).

71. Cited by Needham, *Science and Civilisation*, 3:276 note d (note 5).

the) lunar lodges. The total number of stars in these group[s] is 783. All of them are connected with particular prefectures and kingdoms, and with officials, palace (affairs) and all kinds of things.[72]

The great astronomer and mathematician Zhang Heng (78–139),[73] a contemporary of Ma Xu, gave independent estimates of stellar numbers. Appointed astronomer royal in 116, he made major contributions to Han celestial cartography. In his "Lingxian" (Spiritual constitution of the universe, ca. 118), of which only fragments are preserved today,[74] Zhang Heng wrote as follows:

North and south of the equator there are 124 [star] groups which are always brightly shining. 320 stars can be named (individually). There are in all 2500, not including those which the sailors observe. Of the very small stars there are 11,520. All have their influences on fate.[75]

Enumeration of 2,500 stars would be an arduous but not necessarily impossible task at this early period. The remarkably precise figure of 11,520 seems incredible, however; this is roughly twice the number of stars visible to the average unaided eye over the entire celestial sphere. It is unfortunate that the quotation above is so brief. Further details might have given valuable insight into Han astrography. Regarding the stars "which the sailors observe," Needham points out that already by the Later Han seafarers were making regular voyages to Southeast Asia, where they would see constellations invisible in China.[76] Even though there are more definite records of the observation of southern stars from near the equator in later dynasties, no illustrations of the south circumpolar asterisms are preserved until the Ming (see below).

Regrettably, the astral charts Zhang Heng produced did not survive for long. In the astronomical treatise of the *Sui shu* it is related that they "got lost in the disturbances (at the end of the Han) and the names and details which they showed were not preserved."[77]

In an extant fragment of the writings of Zhang Heng is found one of the earliest clear descriptions of the *huntian* theory of the universe, a rival of the *gaitian* (covering heaven, i.e., hemispherical dome) and *xuanye* (infinite empty space) theories:

The heavens are like a hen's egg and as round as a crossbow bullet; the earth is like the yolk of the egg, and lies alone in the centre. Heaven is large and earth small. . . .

The circumference of the heavens is divided into 365¼° [*du*]; hence half of it, 182⅝° [*du*], is above the earth and the other half is below. This is why, of the 28 *xiu* . . . , only half are visible at one time.[78]

In 117 Zhang Heng built a rotating celestial globe that appears to have accurately represented the constellations:

Zhang Heng . . . constructed a celestial sphere [*huntian*], which included the inner and outer circles, the south and north (celestial) poles, the ecliptic and the equator . . . the stars within (i.e. north of) and without (i.e. south of) the twenty-eight lunar lodges, and the paths of the sun, the moon, and the Five Planets. The sphere was rotated by a water (clock), and was placed (in a chamber) above a (palace) hall. The transits, rising and setting of heavenly bodies (shown on the sphere) in the chamber reflected those in the (actual) heavens.[79]

This sphere, which had a circumference of 14.61 *chi* (3.4 m), was carefully preserved for two centuries after its manufacture, but it eventually met an ignominious fate. In 316, the northern half of China fell into the hands of nomadic invaders. Nothing was heard of the celestial globe until a century later, when the city of Chang'an was recaptured. When the instruments of Zhang Heng were examined, however, "although the forms [of the instruments] were still recognisable, the marks of graduation had all gone, and nothing was left of the representation of stars, sun, moon and planets."[80]

It is unfortunate that no original charts having any pretensions to accuracy are known to exist from the Han dynasty—or indeed until well into medieval times. A number of Han representations of constellation patterns are still extant, some having been unearthed in recent years,[81] but these tend to be decorative rather than func-

72. Translated by Ho, *Astronomical Chapters*, 66 (note 4), from the *Han shu* account as copied in chap. 11 of the *Jin shu*.

73. For a brief biography of Zhang Heng, see Yu-che Chang, "Chang-Hen, a Chinese Contemporary of Ptolemy," *Popular Astronomy* 53 (1945): 122–26.

74. The main source of quotations from the "Lingxian" is the *Yang Hui suanfa* (Yang Hui's methods of computation), a collection of Yang Hui's work and other books, written in 1275.

75. Translated by Needham, *Science and Civilisation*, 3:265 (note 5). (Throughout this chapter, the parenthetical notes in translations from Needham have sometimes been omitted.)

76. Needham, *Science and Civilisation*, 3:265 note d (note 5).

77. *Sui shu*, chap. 19, translated by Needham, *Science and Civilisation*, 3:264 (note 5).

78. Translated by Needham, *Science and Civilisation*, 3:217 (note 5). The adopted units, *du* (degrees of 365.25 to a circle), were chosen because the average daily motion of the sun relative to the background stars is one *du* (i.e., 0.986 degree). For most purposes it is convenient to translate *du* as degrees. For more on the *huntian* and *gaitian* theories, see above, pp. 117–24.

79. Translated by Ho, *Astronomical Chapters*, 59 (note 4).

80. Chapter 23 of the *Song shu* (History of the [Liu] Song), compiled 492–93 by Shen Yue, translated by Joseph Needham, Wang Ling, and Derek J. de Solla Price, *Heavenly Clockwork: The Great Astronomical Clocks of Medieval China*, 2d ed. (Cambridge: Cambridge University Press, 1986), 95–96. Most of the parenthetical notes in translations from *Heavenly Clockwork* are omitted here.

81. For illustrations of several of these artifacts, see *Zhongguo gudai tianwen wenwu tuji* (note 6).

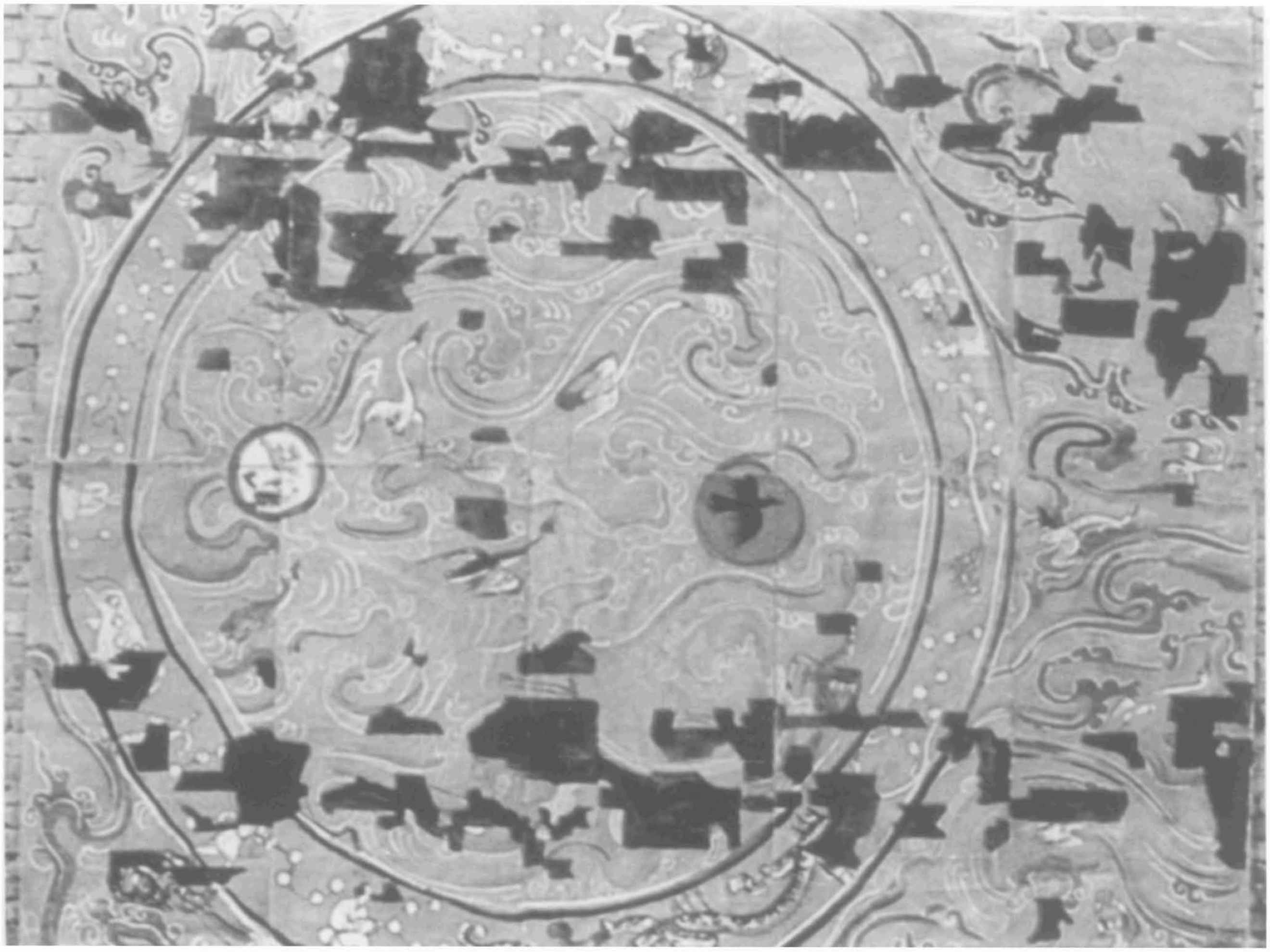


FIG. 13.4. COPY OF A PAINTING OF LUNAR LODGE ASTERISMS FOUND ON THE CEILING OF A TOMB AT XI'AN. A recent careful copy at full scale of a painting discovered on the ceiling of a Former Han tomb. In the ring at the edge of the picture are depicted the twenty-eight lunar lodges in order (commencing at the lower right and moving counterclockwise).
Diameter of the inner circle: ca. 2.5 m. Jiaotong University, Xi'an. By permission of Zhong Wanmai.

tional and typically include only a few inaccurately delineated star groups.

In 1987 the earliest known illustration of all the lunar lodge asterisms was discovered at Xi'an, near the site of the Former Han capital of Chang'an (fig. 13.4).[82] It is painted on the arched ceiling of a tomb that came to light at Jiaotong University, and its estimated date is toward the end of the Former Han, as indicated by coins and other objects found within tomb. The twenty-eight *xiu* asterisms are roughly sketched in a narrow band (some 25 cm wide) around the edge of a circle with an approximate diameter of 2.5 meters. Within this circle are depicted typically Daoist representations of the sun and moon, and also clouds and cranes. Predominant colors are blue, turquoise, red, white, and black.

The painting appears to have been deliberately defaced by grave robbers in antiquity. Although its general state of preservation is poor, several of the constellation patterns are still intact. Stars are denoted by circles of approximately equal size; there seems to be no attempt to display relative brightness. Individual stars are joined into groups by short straight lines. Both of these characteristics are typical of star charts throughout later Chinese history. The circular band portraying the lunar

82. See Shaanxi Sheng Kaogu Yanjiusuo (Shaanxi Archaeological Institute) and Xi'an Jiaotong Daxue (Xi'an Jiaotong University), "Xi'an Jiaotong daxue Xi Han bihua mu fajue jianbao" (Preliminary report on the excavation of the Western Han tomb with murals in Xi'an Jiaotong University), *Kaogu yu Wenwu*, 1990, no. 4:57–63; also Luo Qikun, "Xi'an Jiaotong daxue Xi Han muzang bihua ershiba xiu xingtu kaoshi" (On the star map showing the twenty-eight *xiu* painted on the wall of a Western Han tomb in the campus construction site of Xi'an Jiaotong University in Shaanxi), *Ziran Kexue Shi Yanjiu* 10 (1991): 236–45. The latter article is accompanied by color photographs showing several sections of this astral map.

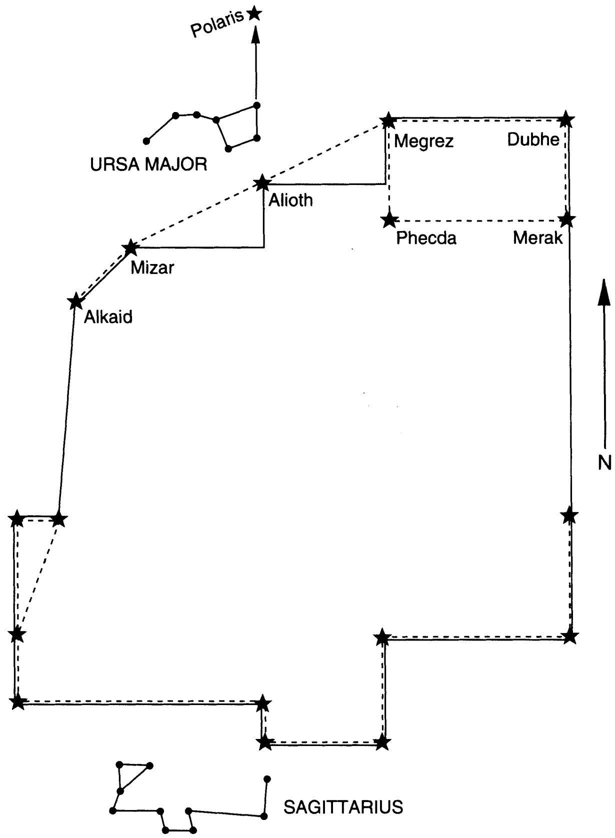


FIG. 13.5. DIAGRAM OF THE HAN CHANG'AN WALLS. Since ancient times, it has been stressed that the northern wall of Han Chang'an (built between 194 and 190 B.C.) took the shape of Beidou (the Northern Dipper, in Ursa Major) while the southern wall resembled Nandou (the Southern Dipper, in Sagittarius). Studies by Hotaling confirm this.
After Stephen James Hotaling, "The City Walls of Ch'ang-an," *T'oung Pao* 64 (1978): 1–46, fig. 22.

lodges also contains illustrations of men, animals, and such, in several cases associated with the constellations themselves.[83] This is an unusual feature; throughout East Asian history, the use of pictorial symbols for the *xiu* is very rare. Normally the star configurations—sometimes highly idealized—are depicted instead. Here we find a marked contrast with Western representations of the signs of the zodiac, which are usually purely symbolic.

What may be a medieval Korean reproduction of a detailed and fairly accurate Han chart is still preserved in a Seoul museum. This planisphere, engraved on marble in 1395, has been damaged over the centuries, but a careful copy to the same scale made in 1687 is in a fine state of preservation (several other late copies are also well preserved). These charts will be discussed in detail below, but let me make a few preliminary remarks at this point.

The Korean map is drawn on a polar (equidistant) projection. Its accompanying inscription relates that it is based on a rubbing of a previous stone chart that had been a gift from China many centuries before. During a war in the Korean peninsula in 670, the original stele had been lost. Calculations based on the positions of the equinoxes as shown on the extant copies of the planisphere indicate an original date toward the end of the first century B.C.[84]

Unique representations of two constellations on an enormous scale appear to have been produced early in the Former Han dynasty. The *Sanfu huangtu* (Yellow plans of the three capital commanderies), probably written sometime between the third and sixth centuries A.D.,[85] gives a detailed account of the building of the walls of the Han metropolis of Chang'an between 194 and 190 B.C. In particular, the text asserts: "The south of the city wall constituted the shape of the Southern Dipper (Nandou = Sagittarius), the north constituted the shape of the Northern Dipper (Beidou = Ursa Major). That until now people refer to the city wall of the Han capital as the 'dou wall' is because of this."[86]

Hotaling, who made a detailed investigation of the city walls of Han Chang'an, remarked that "it is the distinctive shape of the north wall which sets Han Changan apart from the hundreds of other walled cities in China." By the use of scale diagrams, he concluded that the two constellations "really fit the shape of the city wall."[87] Since the length of the north wall was some seven kilometers and that of the south wall only about one kilometer less, these would be the largest representations of star groups ever constructed by any civilization (fig. 13.5).

Roofing tiles from the ruins of Chang'an, depicting the four mythical creatures denoting the nonpolar celestial palaces, were discovered between 1956 and 1958.[88] As in later illustrations (see below), the Dark Warrior (a symbol of the Northern Palace) is shown as a turtle entwined with a snake, though the Azure Dragon, White Tiger, and Red Bird are depicted in more recognizable fashion.

83. For example, the lunar lodge Niu (Ox) is superimposed on a picture of an ox. Unfortunately, many other illustrations are extensively damaged. For a nontechnical account in English, with color photographs, see F. Richard Stephenson, "Stargazers of the Orient," *New Scientist* 137, no. 1854 (1993): 32–34.

84. The derivation of this date is outlined below, pp. 563–64. The term planisphere is used in this chapter to describe a circular map—often on a polar projection—of one or both hemispheres of the night sky.

85. For this suggested date of the *Sanfu huangtu*, see Dubs in Ban Gu, *The History of the Former Han Dynasty*, 3 vols., trans. Homer H. Dubs (Baltimore: Waverly Press, 1938–55), 1:125 n.

86. Translated by Stephen James Hotaling, "The City Walls of Ch'ang-an," *T'oung Pao* 64 (1978): 1–46, quotation on 6.

87. Hotaling, "City Walls," 29, 39 (note 86).

88. Pan, *Zhongguo hengxing guance shi*, pl. 3 (note 7). Samples of these tiles are exhibited in the National Museum of Shaanxi History in Xi'an.

Stellar coordinates have been briefly alluded to above. Unlike the ecliptic framework adopted in the West until recent centuries, Chinese celestial coordinates were equatorial and corresponded closely to the modern system of declination and right ascension (RA).[89] The coordinate in place of declination was known as *qiujidu* (degrees from the pole). This was equivalent to the modern north polar distance (NPD) and was measured from the celestial pole of the time. Positions were expressed in *du*, closely equivalent to degrees (see above).

Writing in the first century A.D., Cai Yong in his *Yueling zhangzhu* (Notes to the Monthly observances) provides important details regarding the use of declination circles on astral charts. He states that three concentric circles were depicted on star maps. The smallest of these was the circle of constant visibility, whose radius was equal to the latitude of the place for which it was constructed. The celestial equator was represented by a circle of intermediate radius. Finally, the outer circle of constant invisibility was set as the limit beyond which no star ever rose above the horizon.[90] The distances between the inner and outer circles and the equator were equal. These same three circles are shown on the Korean chart already mentioned and also on several maps that survive from the Five Dynasties (907–60) and subsequent periods. Clearly, this early tradition became well established in later East Asian history.

In specifying RA, the astronomers of China did not employ a single coordinate origin (such as the vernal equinox). Instead, they measured the positions of celestial bodies eastward from a series of twenty-eight unequally spaced local meridians. These meridians were defined by selected determinative stars (*juxing*), one in each of the lunar lodges; coordinates measured relative to them were termed *ruxiudu* (degrees within a lodge). The term *xiu* came to imply both the asterism itself and the zone of RA it covered. As in the case of north polar distance, RA was expressed in *du*. The equatorial extension of a particular *xiu* (the angular separation between the standard meridian of that lodge and the adjacent reference meridian of the next *xiu* to the east) could range from as small as one or two degrees to some thirty-three degrees.

The determinative stars of the twenty-eight lunar lodges, along with their computed equatorial angular extensions (to the nearest degree) during the Han dynasty are listed in table 13.1. Column 3 of this table gives the modern constellation reference (Bayer Greek letter or Flamsteed number) of each determinant star according to Maeyama,[91] while column 4 specifies the width of each *xiu* in degrees.

As Biot noted more than a century ago, there is a marked correlation between the widths of *xiu* differing in number by fourteen, as exemplified by the two widest lunar lodges, Nandou (no. 8) and Dongjing (no. 22).[92] This feature has yet to be satisfactorily explained. A hint as to why the *xiu* have such uneven spacing is found in the astronomical treatise of the *Shi ji*. This work notes the correspondence in RA between the stars of Beidou and certain of the lunar lodges (Jue, Nandou, and Shen). Biot demonstrated that the determinative stars of a variety of lunar lodges were originally chosen on account of the agreement in RA between these and circumpolar stars.[93] We might thus expect that down through the centuries the choice of certain *xiu* determinatives would be altered to allow for differential precession between the circumpolar stars and the much more southerly lunar lodges. Tradition appears to have played an important role, however. Needham quotes evidence that by medieval times any links between the *xiu* and circumpolar stars had been forgotten.[94] Not until the Ming dynasty do any changes appear to have been made in the determinant stars of the *xiu* (see below).

Numerous solar eclipses are recorded in chapter 27 of the *Han shu*, and for most of these an estimate of the RA of the sun is quoted, expressed to the nearest *du*.[95] For example, in 181 B.C., the totally eclipsed sun was said to be nine degrees in Yingshi. Since the RA of the determinative star of Yingshi (α Peg) was 319 degrees at the time, this corresponds to an RA of 328 degrees. Although the Former Han data prove to be rather crude (average error some five degrees), by the Later Han the corresponding results were of fair precision (mean error two degrees).[96]

89. Declination is a celestial coordinate equivalent to the latitude of the earth's surface. Right ascension (RA) corresponds closely to terrestrial longitude. In modern astronomical practice RA is measured parallel to the celestial equator from the vernal equinox through 360 degrees or 24 hours.

90. This summary of the text by Cai Zhu is given by Bo Shuren, "Astrometry and Astrometric Instruments," in *Ancient China's Technology and Science*, comp. Institute of the History of Natural Sciences, Chinese Academy of Sciences (Beijing: Foreign Languages Press, 1983), 15–32, esp. 18.

91. Maeyama, "Oldest Star Catalogue" (note 54).

92. J. B. Biot, review of *Ueber die Zeitrechnung der Chinesen* by Ludwig Ideler, *Journal des Savants*, 1839, 721–30, and 1840, 27–41.

93. However, several *xiu* determinatives cannot be keyed to circumpolar stars. See T. Kiang, "Notes on Traditional Chinese Astronomy," *Observatory* 104 (1984): 19–23.

94. Needham, *Science and Civilisation*, 3:239 (note 5). Needham notes that in the *Mengxi bitan* (Brush talks from Dream Brook), composed by Shen Kuo about 1088, the administrator of the imperial observatory had asked Shen why the equatorial extensions of the *xiu* were so unequal. He had replied that it was because of the convenience of having them in whole numbers of degrees. He was thus unaware of the true explanation.

95. For a compilation and translation of Former Han records of solar eclipses, see Ban, *Former Han Dynasty*, esp. 3:544–59 (note 85).

96. These figures are based on my own unpublished analysis. See also N. Foley, "A Statistical Study of the Solar Eclipses Recorded in Chinese

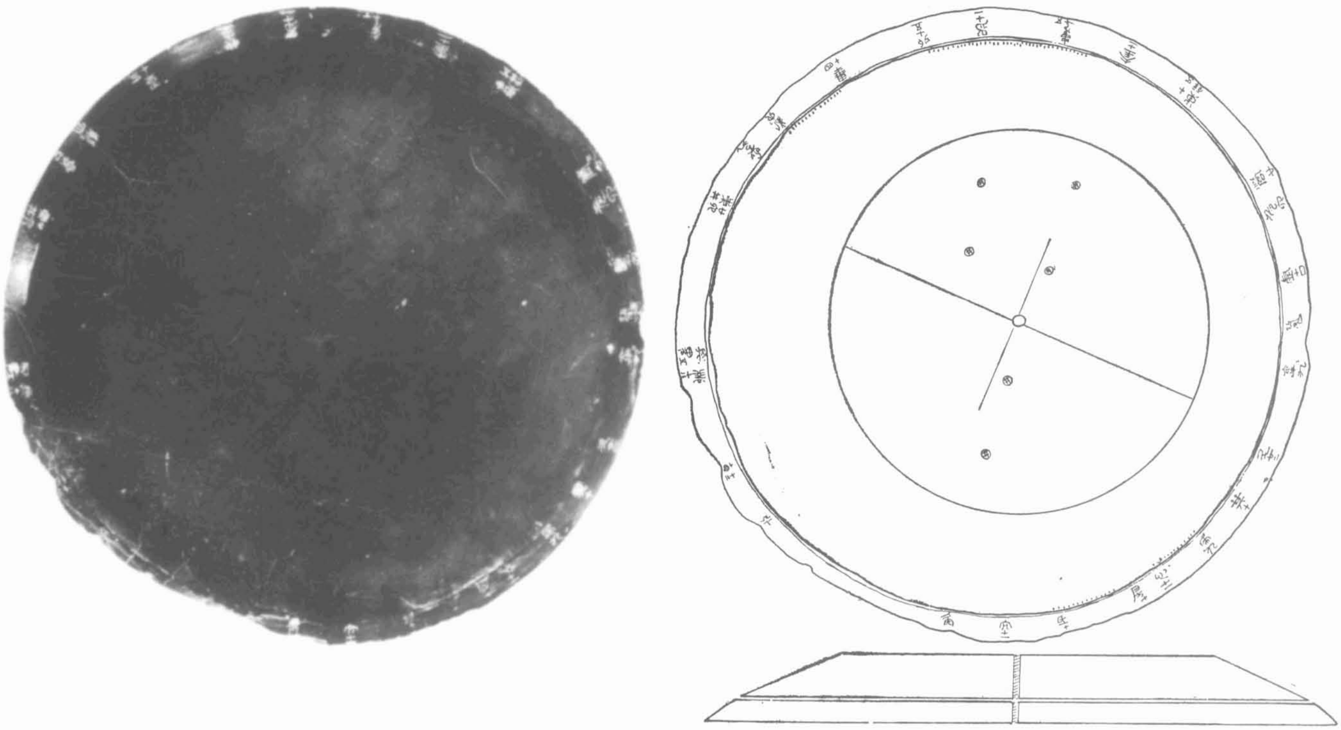


FIG. 13.6. INSCRIBED HAN LACQUER DISK SHOWING IRREGULAR SPACING OF *XIU*. Found in the tomb of a Han nobleman who died in 169 B.C., this instrument is the earliest to show the uneven angular extent of the lunar lodges. It may have been a prototype for a cosmic board, or *shi*. On the right is a reconstruction of the two parts; on the left is a photograph of the rim with the names of the lunar lodges.

Diameter of the original: 25.6 cm. By permission of Anhui Province Fuyang Regional Museum (left). Reconstruction (right) from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo (Archaeological Research Institute, Chinese Academy of Social Science [Academia Sinica]), *Zhongguo gudai tianwen wenwu tuji* (Album of ancient Chinese astronomical relics) (Beijing: Wenwu Chubanshe, 1980), 115.

The practice of using the *xiu* to specify RA is analogous to the Ptolemaic system of expressing celestial longitude relative to one of the twelve zodiacal signs, a method that was in common use in Western astronomy until recent centuries. However, apart from the choice of equatorial instead of ecliptic coordinates and the greater number of divisions, there are other fundamental differences between the lunar lodge system and the Occidental zodiac, notably the nonuniform extent of individual *xiu*.[97]

It is well known that the *xiu* have several features in common with the Indian *nakṣatras*—star groups "in the path of the moon." Thus Vedic lists from about 1000 B.C. cite either twenty-seven or twenty-eight *nakṣatras*. Yet a recent investigation by Pingree and Morrissey argues strongly against a common origin or even association.[98] From some unknown period, the *nakṣatras*—in common with the *xiu*—also had determinative stars (*yogatārās*), but measurements of the positions of these stars cannot be traced until the fifth century A.D. (in such works as the *Paitāmahasiddhānta*). From these relatively recent measurements it is evident that about one-quarter of the *yogatārās* coincide with determinative stars of the *xiu*, though there are major differences between the choices of many of the remaining determinatives. Whatever the explanation for similarities between the two systems, by the fifth century A.D. the *xiu* had already been firmly established in Chinese astronomy for many centuries. On present evidence, it would be difficult to argue a convincing case for the development of the *xiu* from the *yogatārā*.

In 1977 an instrument showing the approximate extent of each of the *xiu* was unearthed in Anhui Province. This device, consisting of an inscribed lacquer disk, was found in the mausoleum of a nobleman who died in 169 B.C.

and Korean History during the Pre-telescopic Era" (M.Sc. diss., University of Durham, 1989).

97. This is, of course, at variance with the primitive concept of the lunar lodges as representing the nightly resting places of the moon.

98. David Pingree and Patrick Morrissey, "On the Identification of the *Yogatārās* of the Indian *Nakṣatras*," *Journal for the History of Astronomy* 20 (1989): 99–119. For more on the Indian *nakṣatras* and their relation to cartography, see Joseph E. Schwartzberg, "Cosmographical Mapping," in *The History of Cartography*, ed. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1987–), vol. 2.1 (1992), 332–87.

(fig. 13.6). It may already have been of considerable age when it was entombed with the body of its owner.[99] The rim, which is graduated in *du*, is marked with the names of the lunar lodges. The instrument provides the earliest direct evidence of the uneven extent of the *xiu*.

In this same burial chamber was found a well-preserved "cosmic board" (*shi*), the oldest example so far discovered.[100] During the 1970s, a number of similar Han devices, made of either lacquer or bronze, were unearthed from other tombs.[101] These were found to have a fairly standard pattern: basically, a circular disk known as the "heaven plate" (*tianpan*) is mounted on a larger square board or "earth plate" (*dipan*). The two plates are connected by a central pin and are free to rotate relative to one another. Near the rim of the disk are engraved the names of the twenty-eight lunar lodges and also the twelve months of the year, while the pattern of the seven stars of Beidou, the Big Dipper, is marked across the center of the disk. The lower plate is inscribed with twelve compass directions and also the names of the *xiu*. Such cosmic boards show the Big Dipper as seen from the outer surface of an imaginary dome of the sky, that is, as portrayed on the surface of a celestial globe. Cosmic boards were used for divination from Han times onward. In particular, they illustrate the importance assigned to the Big Dipper in ancient China as a symbol of celestial power.[102]

The oldest complete listing of the equatorial extensions of the *xiu* is to be found in the *Huainanzi* ([Book of the] Master of Huainan, ca. 120 B.C.), a Daoist treatise. This was presented to the emperor Wu of the Former Han in 139 B.C. by his uncle, Liu An (d. 122 B.C.), the prince of Huainan (in modern Anhui Province). At the time, it was said to have been recently completed. The emperor was so pleased that he had the book placed in his private library. An unpublished analysis that I have made of the widths of the lunar lodges recorded in chapter 3 of the *Huainanzi* indicates a mean error as small as 0.5 degree.

Both Han official histories often give descriptions of the apparent paths of comets across the sky.[103] Such records are particularly interesting from the uranographic point of view, since, unlike the moon and planets, comets are not confined to the ecliptic zone. For example, the account in chapter 27 of the *Han shu* of the motion of Halley's comet in 12 B.C. notes the passage of the comet through or near more than ten separate asterisms.[104] Such records provide a valuable test of the accuracy of modern theories of the motion of this famous comet. Cometary records before the middle of the second century B.C. seldom mention constellations apart from the *xiu*, but afterward many star groups to the north and south of the lunar lodges are referred to as well. Although this feature may be significant, let me emphasize that only summaries of the original observations now exist, possibly with the loss of key information.

A report in the *Han shu* of a comet in 138 B.C. is especially interesting, since it makes one of the first known mentions of two of the three *yuan* (enclosures), major groupings of constellations bounded by fairly well defined chains of stars.[105] These are the Taiwei (Supreme Subtlety) and Ziwei (Forbidden Purple) enclosures, situated respectively in the Leo/Virgo region and the north circumpolar zone. (The other *yuan* is the Tianshi [Celestial Market] enclosure, situated largely in Hercules and Ophiuchus.) In astrology the Taiwei *yuan* was particularly important, since it was crossed by the ecliptic and hence lay in the path of the moon and planets. The Ziwei *yuan* formed the approximate boundary of the region within which stars were permanently above the horizon as seen from north-central China.

Occasional entries in the *Han shu* (after about 50 B.C.) indicate that by this period uranography had progressed to the extent that individual stars in at least some asterisms were assigned reference numbers. Thus, in recording a possible nova that appeared during the spring of 48 B.C., the *Han shu* states that a guest star (*ke xing*) was "about 4 *cun* [roughly 0.4 degree] east of the second star of Nandou."[106] Use of stellar reference numbers is relatively rare in Han records, but from the Jin dynasty (265–420) onward it was commonplace (see below).

A valuable indication of how far the night sky had been mapped by the Former Han is provided by the two major star catalogs that are preserved from this period.

99. A drawing of this instrument is provided by Yin Difei, "Xi Han Ruyinhou mu chutu di zhanpan he tianwen yiqi" (Divination board and astronomical instruments from the Western Han tomb of the marquis of Ruyin), *Kaogu*, 1978, 338–43.

100. Yin, "Xi Han Ruyinhou mu chutu di zhanpan he tianwen yiqi" (note 99), provides a photograph of this instrument.

101. Brief details are supplied by Harper, "Han Cosmic Board" (note 39), who also cites primary references in Chinese journals. Much of the subsequent description is based on that given by Harper.

102. For an interesting Han account of the use of divination boards, see chap. 99 of the *Han shu*; modern edition in 7 vols. (Beijing: Zhonghua Shuju, 1970). A translation is given by Dubs in Ban, *Former Han Dynasty*, 3:463–64 (note 85).

103. Translations of these records are given by Ho Peng-yoke, "Ancient and Mediaeval Observations of Comets and Novae in Chinese Sources," *Vistas in Astronomy* 5 (1962): 127–225, 143 ff. Chapter 26 of the *Han shu* is titled "Tianwen zhi" (Treatise on astrology). Chapter 27, "Wuxing zhi" (Treatise on the five phases), devoted mainly to meteorological phenomena, also contains many records of such celestial phenomena as comets and eclipses.

104. A translation and discussion of this record is given by Stephenson and Yau, "Far Eastern Observations," 201–2 (note 2).

105. *Han shu*, chap. 26 (note 102), see also Ho, "Ancient and Mediaeval Observations," 144 (note 103).

106. *Han shu*, chap. 26 (note 102), see also Ho, "Ancient and Mediaeval Observations," 147 (note 103).

These are contained respectively in the *Shi ji* and the *Xingjing*; the compilation in the latter work has already been briefly referred to.

The constellation list in chapter 27 of the *Shi ji* is the earliest to cover the whole sky visible from China. Although the star inventory in the *Xingjing* (*Kaiyuan zhanjing*, chaps. 60–63) appears to be roughly contemporaneous with it, the versions of this latter work that are preserved today are incomplete. In the *Shi ji*, Sima Qian gives brief descriptions of approximately one hundred asterisms (including the *xiu*). These are divided into the five celestial palaces of unknown antiquity: the Central Palace (Zhonggong), Eastern Palace (Donggong), Southern Palace (Nangong), Western Palace (Xigong), and Northern Palace (Beigong). Of these five regions, the Central Palace—also known as the Forbidden Purple Palace (Ziweigong)—was circular; it was the domain of the north circumpolar stars, which never set from the latitudes of northern China. The remaining four palaces took the form of truncated sectors, extending from the circle of constant visibility to the circle of constant invisibility. Among these latter divisions, the Eastern Palace was symbolized by the Azure Dragon (Canglong), the Southern Palace by the Red Bird (Zhuniao), the Western Palace by the White Tiger (Baihu), and the Northern Palace by the Dark Warrior (Xuanwu). Sima Qian's account is more or less repeated in chapter 26 of the *Han shu*, written some two centuries later. Not until the seventh century do we find lists of the constellations that are appreciably more extensive.

Commencing with the circumpolar stars—in the Central Palace—the *Shi ji* gives a qualitative description of each asterism. Star groups in the Eastern Palace, which covers the approximate range of RA from 12 hours to 18 hours, include the first seven lunar lodges; those in the Northern Palace (18 hours to 24 hours) the second seven *xiu*; and so on for the Western Palace and Southern Palace.[107] Positional measurements are absent, and the relative locations of individual asterisms are only vaguely described. As is clear from the frequent allusions to augury, one of the principal motives for compiling this catalog was astrological.[108]

In describing the various constellations, the *Shi ji* is by no means consistent. For some important asterisms, such as Beidou, the constituent stars are individually named. Often the number of stars in a particular group is specified, but this is not always the case, even for the lunar lodges. When cited, the number of stars in an asterism can vary from only one—as in the case of Lang (Sirius) or Laoren (Canopus)—to more than ten. In general, Chinese asterisms were much smaller in extent than the Western constellations.

Most of the names of star groups in the *Shi ji* are identical with those found in later writings. These designations tend to be prosaic compared with those of Western constellations. Instead of gods and goddesses, we find a reflection of the Chinese empire, for example: the emperor and his family; ministers and generals; domestic animals; buildings such as palaces, markets, prisons, and stables. When a change in the appearance of an asterism occurred or a celestial body entered it, this was believed to presage an event involving the terrestrial equivalent.

Reference to the *Shi ji* and later star lists shows that correspondence between Chinese and Babylonian-Greek names for constellations is rare, emphasizing their independent origins. Apart from Beidou, whose ladle shape is so obvious, little more than Wei, another well-defined star group, and Lang can be cited. Wei represents the tail of the Dragon in Chinese uranography and the tail of the Scorpion in the Occident. Lang (Wolf) is equivalent to the brilliant Sirius, the Dog Star. Whereas Sirius is a member of the constellation Canis Major, however, Lang was regarded as an isolated star.[109]

Among the entries in the *Shi ji* catalog, eleven stars are described as "large." Bo has noted that practically all of these are among the brightest stars observed today, but his efforts to suggest that Sima Qian recognized as many as five grades of brightness are far from successful.[110] Whereas Ptolemy grouped the stars into six classes (1 = brightest; 6 = faintest, the foundation of the modern system of stellar magnitudes), no comparable scheme ever found favor in China in the pre-Jesuit period. Provided even a faint star was recognized as an established member of a constellation, its astrological importance seems to have been no less than that of the brighter constituents of the same group.

The *Xingjing*, dated by both Maeyama and Yabuuchi

107. The actual order of the four noncentral palaces in chap. 27 of the *Shi ji* is East, South, West, North. Owing to the irregular widths of the *xiu*, the true angular extent of these palaces ranges from about 75 to 110 degrees.

108. For example, an entry in the *Shi ji*, chap. 27 (note 28), describes the lunar lodge Xin, which consists of the three stars in Scorpio (σ Sco, Antares, and τ Sco): "Xin (Heart) represents the 'Hall of Brilliance.' The large star is the Heavenly King; the front and rear stars represent his sons. It is an unfavorable omen when (the stars) are in a straight line. When they are in a straight line, the Heavenly King will err in judgement" (my translation). Even in later times, Chinese astronomers believed that the relative positions of the stars in a constellation could change to some extent, a curious notion that suggests lack of careful measurement of any but the principal star in each group. See chap. 11 of the *Jin shu* (note 14) and other Chinese treatises on astrology.

109. For remarks on the few similarities between pictorial representations of the constellations as found in China and the Occident, see below.

110. Bo Shuren, "Sima Qian—The Great Astronomer of Ancient China," *Chinese Astronomy and Astrophysics* 9 (1985): 261–67. Bo was able to find very few references to the brightness of stars other than for the small number described as "large."

to within about thirty years of 70 B.C.,[111] contains accurate positional information for 120 star groups. In addition to the twenty-eight lunar lodges, sixty-two asterisms to the north of the *xiu* and thirty asterisms to the south are cataloged. Apart from the lunar lodges, the present list cites only star groups in the Central Palace, Eastern Palace, and Northern Palace. The text as found in the *Kaiyuan zhanjing*—and also in the Daozang, under the title *Tongzhan daxiangli xingjing* (The great firmament star manual common to astrology)—is accompanied by rough sketches of each asterism, though these are not necessarily of early date.

Although the star catalog in the *Xingjing* is incomplete, the original version presumably included many similar measurements of position for asterisms in the Western Palace and Southern Palace. The preserved portions of the catalog appear to be representative of a systematic survey of the whole of the night sky as visible from north-central China.

From a careful investigation, Maeyama was able to confidently identify virtually all of the principal stars in the 120 asterisms listed in the *Xingjing*.[112] After correcting a few obvious copyist's errors, he found that the real accuracy of positional measurements was typically to within about one degree. Measurements of such precision were probably made with the aid of an armillary sphere. The construction of such a device, consisting of a sighting tube attached to a single polar-mounted declination ring, is attributed in later Chinese history to Luoxia Hong about 104 B.C. We know, however, that at least by 52 B.C. a second ring (at right angles to the first) had been added.[113]

The *Xingjing* determinations of celestial latitude, measured north and south of the ecliptic (the Huangdao, or Yellow Road)[114] are particularly interesting; they reveal that the apparent annual path of the sun through the constellations was already clearly defined. The earliest known estimates of the ecliptic extensions of the lunar lodges date from the Later Han; these are contained in chapter 13 of the *Hou Han shu*.[115] But it should be stressed that throughout Chinese history much more emphasis was placed on equatorial coordinates.

The Three Kingdoms to the Sui Dynasty (220–618)

The troubled centuries following the end of the Han were characterized by extensive astronomical activity—often independently in northern and southern China. Although we know that several major astral charts and celestial globes were produced during this period, none are extant. Instead, only a few crude maps of the stars are preserved.

Histories written centuries afterward mention the production of both star maps and celestial globes during the Three Kingdoms period (220–65), but the available information is tantalizingly brief. A stellar chart compiled by the Wu astronomer royal Chen Zhuo (fl. late third century A.D.) has already been mentioned in passing. This was produced sometime between 265 and 280. According to the *Jin shu*, the map constructed by Chen Zhuo depicted 1,464 stars in 283 groups.[116] A few additional details are found in the *Sui shu*. After commenting on the loss of Han star maps in the disturbances that accompanied the downfall of the Later Han dynasty, the *Sui shu* continues as follows:

> But then Chen Zhuo Astronomer-Royal of the Wu State (in the Three Kingdoms period) first constructed and made a map of the stars and constellations according to the three schools of astronomers, Master Gan, Master Shi, and Wu Xian, adding an explanation with an astrological commentary. There were 254 constellations, 1283 stars, and 28 *xiu*, with 182 additional stars, making in all 283 constellations and 1565 stars.[117]

There is an obvious error in the text above, for the total number of stars should be 1,464 rather than 1,565. Here we find a recurrence of the tradition of detailed uranography developed during the Zhanguo. The number of "additional stars" (in the twenty-eight lunar lodge asterisms) is interesting. Han compilations (including the extant versions of the *Xingjing*) assign only 164 stars to the *xiu*, but lists from the early Tang dynasty (618–907) onward include additional stars in six of the lunar lodges, making a total of 182,[118] identical with the figure attributed to Chen Zhuo. Possibly he himself was responsible for revising the number of stars in the *xiu*; there appear to have been no major amendments after his time. Regrettably, apart from the numbers of asterisms and stars depicted, nothing is known concerning the map Chen Zhuo made. He is also known to have written several books on astronomy and astrology, including

111. Maeyama, "Oldest Star Catalogue" (note 54), and Yabuuchi, "*Sekishi Seikyo* no kansoku nendai" (note 55).

112. Maeyama, "Oldest Star Catalogue" (note 54).

113. See, for example, Ho, *Li, Qi and Shu*, 124–25 (note 16).

114. The celestial equator was known as the Chidao, or Red Road.

115. See Maeyama, "Astronomical Data of Ancient China," 269 ff. (note 69).

116. See p. 518. According to chap. 11 of the *Jin shu* (note 14), Chen Zhuo produced his astral chart when the first Jin emperor Wudi (265–90) was on the throne. Since the Wu state was annexed by the Jin empire in 280, the date range reduces to between 265 and 280.

117. From the astronomical treatise of the *Sui shu*, chap. 19, translated by Needham, *Science and Civilisation*, 3:264 (note 5).

118. See, for example, chap. 11 of the *Jin shu* (note 14).

Xingshu (Description of the stars), which survived until at least the twelfth century.[119]

The *Jin shu* attributes some kind of celestial globe (*huntian*) to Lu Ji (fl. 220–45), who—like Chen Zhuo—was an astronomer of Wu State.[120] According to the *Sui shu*, a third astronomer of Wu, named Ge Heng (fl. 250), constructed a device "to show the earth fixed at the center of the heavens; these were made to revolve by a mechanism while the earth remained stationary."[121] In both cases the details are fragmentary. The Wu astronomer and mathematician Wang Fan (219–57) criticized earlier celestial globes as being either so small that the stars were overcrowded or so large that turning them was difficult. He remarked: "I have therefore re-designed the celestial sphere by taking a scale of 3 *fen* to each degree (*du*). The whole of the heavens are thus represented by a sphere with a circumference of 1 *zhang* 1 *chi* 9 *cun* and 5¾ *fen* (approx. 2.52 metres)."[122] Unfortunately, nothing is known regarding the representation of the stars on this globe. According to the *Jin shu*, the various instruments Lu Ji and Wang Fen produced all disappeared after nomadic invaders overran northern China early in the fourth century.[123]

Information on the production of star maps and celestial globes during the Jin dynasty (265–420) is negligible. Nevertheless, the extensive astronomical observations from this period recorded in the *Jin shu* (and also in the *Song shu*) seem to imply the existence of good astral charts. Numerous observations of passages of the moon, planets, comets, and meteors through or close to asterisms are preserved, and many constellations are noted in addition to the twenty-eight *xiu*.

The assignment of a reference number to individual stars within asterisms during the Han has already been mentioned. Extant Jin records contain many examples of the following form: "the moon concealed the second star of Xuanyuan [an asterism in Leo]" or "Venus invaded the second star from the south of Fang [in Scorpio]." By computing the position of the moon or planet on the appropriate date, it becomes possible to identify certain individual stars within asterisms near the ecliptic.[124] Although such numbering schemes continued in use until relatively modern times, it has yet to be established whether significant variations occurred through the centuries.

The Jin dynasty was succeeded by the Liu Song dynasty, 420–79 (one of the Six Dynasties). Not long afterward, a bronze celestial globe was constructed at Nanjing by the astronomer royal Qian Luozhi (who also produced a bronze armillary sphere). On this device, a wide variety of constellations was depicted using colored pearls, though there is disagreement regarding the individual colors. The earliest account, in the *Song shu*, runs as follows:

> In the seventeenth year [of the Yuanjia reign period, i.e., 440] a small astronomical instrument [*huntian*, a celestial globe] was also made, of diameter 2.2 *chi* (0.54 m) and circumference 6.6 *chi* (1.6 m), with (two) tenths of a *cun* (5 mm) to a degree. The twenty-eight lunar lodges were fixed on, and pearls of three colours, white, black and yellow, represented the stars of the three schools of astronomers. The sun, moon and five planets were again attached to the ecliptic [as in the case of the armillary sphere produced four years earlier by Qian Luozhi].[125]

The *Sui shu* differs on the colors used to represent the various stars. It gives two slightly different accounts in separate sections of its astronomical treatise (both in chap. 19). One of these gives a description similar to that in the *Song shu* but adds, "The twenty-eight [lunar lodges] and all the constellations both north and south of the equator were indicated by pearls of three colours, white, green and yellow, according to the three schools of astronomers."[126] The other account asserts that the stars were denoted by red, black, and white, adding that the total numbers of stars of each color agreed with those enumerated by Chen Zhuo. In the various preserved texts there is possibly some confusion between the features of the armillary sphere (*hunyi*) and celestial globe (*huntian*) manufactured by Qian Luozhi.

This practice of marking the stars on celestial globes and charts in three colors continued in China during the medieval period.[127] It also spread to Korea, where it was still in vogue in the eighteenth century (see below). Whether it actually reflected traditions originating in the Zhanguo is still unanswered. Although no information

119. See Needham, *Science and Civilisation*, 3:207 and 264 note e (note 5).

120. *Jin shu*, chap. 11 (note 14).

121. Wei Zheng et al., *Sui shu*, chap. 19; see the modern edition in 6 vols. (Beijing: Zhonghua Shuju, 1973).

122. Translated from chap. 11 of the *Jin shu* by Ho, *Astronomical Chapters*, 66 (note 4).

123. *Jin shu*, chap. 11 (note 14).

124. For a discussion of the identity of fifty zodiacal stars mentioned in Chinese texts of the fourth to sixth century A.D., see Liu Ciyuan, "You yueliang yanfan jilu dedao di wushike huangdao xing di dong Jin Nanbei chao shiqi xing ming" (Names of fifty stars on the ecliptic during the Eastern Jin and Northern and Southern dynasties, obtained from records of close lunar conjunctions), *Tianwen Xuebao* 27 (1986): 276–78 (English abstract on 278).

125. From the astronomical treatise of the *Song shu*, chap. 23, translated by Needham, Wang, and Price, *Heavenly Clockwork*, 96 (with slight amendments) (note 80).

126. Translation from Needham, Wang, and Price, *Heavenly Clockwork*, 97 (note 80).

127. For example, Needham, *Science and Civilisation*, 3:264 (note 5), remarks: "That star-maps showing the traditional colors still existed in A.D. 1220 we know from a story about an unfortunate examination candidate Xu Ziyi."

is available on the accuracy with which the stars were displayed on the celestial globe of Qian Luozhi, it was apparently still in use when China was unified under the Sui dynasty in 581. Thus it was reported that the armillary sphere and globe made by Qian were both taken to Chang'an in that year, and sixteen years later they were moved to the astronomical observatory at Luoyang.[128] Nothing further is heard of these instruments after 605.

During the Liu Song, the first extant measurements were made of the NPD of the Pole Star. For many centuries the bright star known as Diwang (Emperor) or Dadi (Great Emperor)—β UMi—had acted as a prominent North Pole marker, though it was never less than seven degrees from the true pole. However, by the Later Han its distance from the celestial pole had increased significantly owing to precession, and the astronomers of the time adopted Niuxing (Pivot star) instead.[129] This latter object, a constituent of the asterism Beiji (North Pole), may be identified with a rather faint star in the constellation of Camelopardalis (32 H Cam). Listed as 2102 in the Smithsonian Astrophysical Catalog (SAO), it is one of the few stars visible to the unaided eye near the path of the celestial pole at this period.

As recorded in the *Sui shu*, the Song astronomer royal Zu Gengzhi (429–500) measured the NPD of Niuxing and found its distance from the "place of nonmovement" (*bu dong chu*) to be rather more than one *du*. This result compares with the calculated distance for SAO 2102 about A.D. 460 of 1.9 degrees.[130]

The star SAO 2102 remained the choice as pole marker for several centuries, eventually being replaced by the present pole star Tianhuang Dadi (Great Celestial Emperor)—α UMi or Polaris.

About 550, a large celestial globe was constructed at the capital of Jiankang (Nanjing). This is described as follows:

> It was made of wood, as round as a ball, several armspans in circumference, and pivoted on the south and north poles, while round the body of it were shown the twenty-eight *xiu*, as also the stars of (each of) the Three Masters, the ecliptic, the equator, the milky way, etc. There was also an external horizontal circle surrounding it, at a height which could be adjusted, to represent the earth.... When the globe rotated from east to west, the stars which made their meridian transits morning and evening corresponded exactly with their degrees ... there was absolutely no difference from the heavens.[131]

The fate of this device is not known. When the first Sui emperor conquered the Chen dynasty of southern China (589), it is recorded that

> he captured their astronomical expert Zhou Fen and the instruments which had been handed down from the (Liu) Song time. Whereupon he ordered Yu Jicai and others to check for size and accuracy the old (star-) maps, both private and official, dating from the (Northern) Zhou, Qi, Liang, and Chen dynasties, and formerly in the keeping of Zu Gengzhi, Sun Senghua, and others. The object of this was the construction of hemispherical maps (*gaitu*) following the positions of the stars of the Three Schools.[132]

The various "old (star-) maps" that were consulted had been produced during the previous hundred years.

Despite the marked interest in uranography throughout the period from the Three Kingdoms to the Sui, only a few stellar charts of this era are preserved. Two of these artifacts merit some comment here. During excavations at Luoyang in 1973, a star map was discovered on the ceiling of a Northern Wei tomb.[133] Dating from 526, this chart—which is some three meters in diameter—portrays the stars as red circles of roughly equal size on a buff background (plate 31). Some stars are linked into groups, but most are unconnected. The whole appearance is rather sketchy, and few asterisms are readily recognizable apart from Beidou. An unusual feature is the importance assigned to the Milky Way, which is shown in blue, bisecting the night sky. This is probably the earliest known pictorial representation of the River of Heaven from China. As noted above, however, allusions to the Milky Way dating from more than a thousand years previously are found in the *Shi jing* poems.

Several years ago, a painting on silk depicting the mythical sage-rulers Fuxi and Nuwa, dating from sometime between 500 and 640, was unearthed from a tomb at Gaochang (modern Turpan, in Xinjiang Province).[134] This is one of several finds of uranographic significance from the extreme northwest of China (on or near the old Silk Road). The painting—which measures about 2.25 meters by 1 meter—displays rough sketches of about thirty star groups in white on a buff background. Part of the Milky

128. *Sui shu*, chap. 19; see Needham, Wang, and Price, *Heavenly Clockwork*, 98 (note 80).

129. Pan, *Zhongguo hengxing guance shi*, 166–69 (note 7), gives a valuable investigation of the history of stars identified by the Chinese as pole markers. This largely supersedes the discussion by Needham, *Science and Civilisation*, 3:259–62 (note 5).

130. *Sui shu*, chap. 19 (note 121).

131. *Sui shu*, chap. 19, translated by Needham, *Science and Civilisation*, 3:384 (note 5).

132. *Sui shu*, chap. 19, translated by Needham, *Science and Civilisation*, 3:264 (note 5).

133. A discussion of this star map, including a color photograph, was published by Wang Che and Chen Xu, "Luoyang Bei-Wei Yuan Yi mu di xingxiangtu" (The celestial map from the Northern Wei tomb of Yuan Yi at Luoyang), *Wenwu*, 1974, no. 12:56–60 and pl. 1. These authors have identified some thirty star groups depicted on the chart. See also *Zhongguo gudai tianwen wenwu tuji*, 8 (note 6).

134. *Zhongguo gudai tianwen wenwu tuji*, 9 and 120 (note 6).

Way is also shown. A very similar painting on silk, dating from 897, was found in a tomb at Dunhuang (Gansu Province) in 1908; it seems that such artifacts were not uncommon in tombs, typically being fixed to the ceiling.[135]

Two intriguing constellation lists that may date from the pre-Tang era deserve special comment, even though neither contains any measurements. Both are poems. The best known of these is attributed to the Sui poet Wang Ximing, whose pen name was Dan Yuanzi (fl. ca. 590). Known as the *Butian ge* (Song of the sky pacer), this work gives a brief description of almost three hundred asterisms and also enumerates the stars in each. Needham suggests that Tan "might perhaps be termed the Aratus or the Manilius of China, though so much later than they."[136] So highly regarded was the *Butian ge* that in later centuries it could be said that "all who have discussed the constellations have taken the *Butian ge* as their standard."[137] In the twelfth century, chanting portions of the poem on clear nights was recommended as a way to gain familiarity with the constellations.[138]

Later texts assert that the poem describes 283 constellations containing a total of 1,464 stars.[139] These figures are identical with the numbers of asterisms and stars said to be represented on the third-century star map of Chen Zhuo.[140]

Two manuscript versions of another constellation poem that may be about as old as, or even somewhat earlier than, the *Butian ge* were discovered at Dunhuang in 1908 and are now in the Bibliothèque Nationale in Paris. Unlike the composition by Wang Ximing, this poem, entitled *Xuan xiang shi* (Poem of the image of the heavens), seems to have had only a limited circulation. The existing renderings (which differ to some degree) were among the numerous manuscripts Pelliot found in the Caves of the Thousand Buddhas at Dunhuang.[141] One of the two manuscripts containing the poem (P. 2512) bears a date that corresponds to 621—at the very beginning of the Tang—but this may be a copy of an earlier original. The date of the other text (P. 3589) is not preserved. An extensive study was made recently by Deng Wenkuan, who was of the opinion that the poem was composed sometime between the Three Kingdoms and Sui eras.[142]

The *Xuan xiang shi* is less detailed than the *Butian ge*, and there is a definite astrological bias that is absent in the poem attributed to Wang Ximing. In addition, the *Xuan xiang shi* (which is of unknown authorship), divides the constellations into three groups according to their association with the astronomers of antiquity Shi Shen, Gan De, and Wu Xian. This is one reason Deng judges the work to be older than the *Butian ge* (which groups the constellations in the various palaces). Deng also notes that elsewhere in manuscript P. 3589 there is an abstract from an astrological work by Chen Zhuo, though neither of these features necessarily indicates an early date.

Remarks on the contents of an unspecified star chart on which the stars were said to be marked in three colors (recalling the celestial globe of Qian Luozhi) are also found in a separate section of manuscript P. 2512.[143] This portion of the text begins with a list of the twenty-eight lunar lodges. For each lunar lodge, the number of constituent stars is stated; in addition, the equatorial extent (in *du*) is given, together with the angular extent of the determinative star from the north celestial pole. These figures are nearly all identical to Han values; they are not the result of contemporaneous measurements. The number of stars in all twenty-eight *xiu* amounts to 182, including 17 stars adjoining six of the lunar lodges. This total is identical to that said to have been included by Chen Zhuo in his chart of the constellations.

The text continues with brief descriptions of 256 additional asterisms to the north and south of the lunar lodges. The first 94 of these star groups are said to be taken from Shi Shen, the next 118 from Gan De, and the remaining 44 from Wu Xian. There is no overlap among the three lists; each contains a separate set of constellations. For every asterism in a set, the number of constituent stars is given, together with a brief qualitative description of the position of the asterism relative to neighboring star groups; there are no measurements.

The final totals of asterisms and stars (284 and 1,464) are virtually identical to the figures cited in the *Jin shu* and *Sui shu* for the chart constructed by Chen Zhuo and the celestial globe of Qian Luozhi. As we will see below, these numbers remained almost canonical even in relatively recent centuries.

135. Pan, *Zhongguo hengxing guance shi*, pl. 25 (note 7).

136. Needham, *Science and Civilisation*, 3:201 (note 5).

137. This remark forms part of the text of an eighteenth-century Korean astronomical screen. See Joseph Needham and Gwei-djen Lu, "A Korean Astronomical Screen of the Mid-Eighteenth Century from the Royal Palace of the Yi Dynasty (Chosŏn Kingdom, 1392–1910)," *Physis* 8 (1966): 137–62, esp. 148.

138. Needham, *Science and Civilisation*, 3:281 (note 5).

139. Needham and Lu, "Korean Astronomical Screen" (note 137).

140. Soothill, *Hall of Light*, 244–51, translates and discusses this poem (note 21).

141. Mark Aurel Stein was the first European to explore the vast archives at Dunhuang. In 1907 he purchased numerous manuscripts for the British Museum. A year later, Paul Pelliot acquired many of the remaining texts for the Bibliothèque Nationale. Finally, the Chinese government removed what was left.

142. Deng Wenkuan, "Bi 'Butian ge' geng gulao di tongshu shixing zuopin—'Xuanxiang shi' " (A popular work for star recognition older than the "Butian ge"—"Xuanxiang shi"), *Wenwu*, 1990, no. 3:61–65.

143. See Maspero, "L'astronomie chinoise," 272 and 319 ff. (note 49). I have based the following details on a microfilm copy of the manuscript text supplied by the Bibliothèque Nationale.

The signs of the Western zodiac were first introduced into China by way of India, during the Sui dynasty. The earliest references in Chinese to the Western zodiac are found in the *Da zang jing* (Great storehouse of sutras), the Chinese translation of the Buddhist Tripiṭaka, in a sutra known as the *Dafangdeng daji jing* (Sutra of the great assembly of bodhisattvas).[144] This text, which forms section 397 of the *Da zang jing*, was translated from the Sanskrit during the Sui. Chapter 42 of the *Dafangdeng daji jing* contains a list of the zodiacal signs governing each of the twelve lunar months. The names may be translated as follows: month 1, Ram; 2, Bull; 3, Pair of Birds; 4, Crab; 5, Lion; 6, Celestial Woman; 7, Steelyard; 8, Scorpion; 9, Archer (literally "to shoot with a bow"); 10, Sea Monster (*mojie*); 11, Water Vessel; 12, Celestial Fish.[145] Most of these names are readily recognizable in terms of the familiar names of the zodiacal constellations, obvious exceptions occurring in months 6 and 10. In particular, *mojie* is a transliteration of the Sanskrit word *makara* (sea monster), the equivalent of Capricorn. It is not until the Tang that we find the first pictorial representations from China of at least portions of the zodiac.

The Tang Dynasty and Five Dynasties Period (618–960)

The Tang (618–907) was a period of great cultural attainment, not least in astronomy. Both of the official Tang histories preserve many careful observations of the motions of the sun, moon, and planets—as well as comets—relative to the constellations,[146] suggesting that accurate representations of the night sky were available to the imperial astronomers of the time. In general, however, survivals of star maps from this dynasty are scarcely better than from earlier periods. Little is known even about to what extent celestial charts and globes were produced during the Tang.

During the seventh and eighth centuries, several Indian astronomers held office at the imperial observatory in Chang'an, the Tang metropolis. Some of these—including Gautama Siddhārtha (Qutan Xida), who compiled the *Kaiyuan zhanjing* in 730—attained the position of astronomer royal,[147] but there is no evidence that they had any significant influence on the development of Chinese uranography. The Indian astronomers were especially concerned with mathematical astronomy, based on Greek methods, for predicting celestial events such as eclipses.

A native Chinese, Yixing (682–727), who was a Buddhist priest as well as a leading astronomer, constructed several important instruments at Chang'an. One of these appears to have been a celestial globe. According to the astronomical treatises of the two official Tang histories, this was "made in the image of the round heavens and on it were shown the lunar lodges in their order, the equator and the degrees of the heavenly circumference."[148] This device was rotated once every twenty-four hours by a water clock. Unfortunately, no further uranographic details are available.

Little information is available on other stellar charts produced during the Tang. Yixing is known to have initiated an expedition to Annam (modern Vietnam), which—among other objectives—observed the southern constellations invisible from China.[149] This took place in 724 and was led by the astronomer royal Nangong Yue, accompanied by Da Xiang and Yuan Tai. Although how fully the southern stars were charted is not recorded, the account in chapter 35 of the *Jiu Tang shu* makes interesting reading:

> Da Xiang and Yuan Tai say that at Jiaju [modern Hanoi, latitude 21°N] if one observes the pole it is elevated above the Earth's surface only a little more than 20°. Looking South in the 8th month from out at sea Laoren (Canopus) is remarkably high in the sky. The stars in the heavens below it are very brilliant and there are many large and bright ones which are not . . . known. In general all the stars which are more than 20° from the southern pole are all visible. Indeed it is the part of the sky which the ancient *Huntian* (Celestial Sphere) school of astronomers regarded as permanently below the horizon and therefore not to be seen.[150]

Chinese navigational charts depicting a few southern asterisms are preserved from the Ming (1368–1644), but not until the time of the Jesuits is there any evidence for extensive mapping of the south circumpolar constellations in China (see below).

144. The *Da zang jing* has been published under the title *Taishō shinshū Daizōkyō* (The Tripiṭaka in Chinese revised by Taishō University), ed. Takakusu Junjirō and Watanabe Kaigyoku, 85 vols. (Tokyo: Taishō Issaikyō Kankōkai, 1924–32). See W. Eberhard, "Untersuchungen an astronomischen Texten des chinesischen Tripitaka," *Monumenta Serica* 5 (1940): 208–62, esp. 232 ff.

145. I am grateful to A. C. Barnes, formerly of Durham University, for valuable comments and advice on the identification of the signs of the Western zodiac as found in the Tripiṭaka.

146. Liu Xu et al., *Jiu Tang shu* (Old history of the Tang, compiled 940–45), chap. 35; see the modern edition in 16 vols. (Beijing: Zhonghua Shuju, 1975). Ouyang Xiu et al., *Xin Tang shu* (New history of the Tang, compiled 1032?–60), chap. 31; see the modern edition in 20 vols. (Beijing: Zhonghua Shuju, 1975).

147. For details, see Yabuuchi, "Researches on the *Chiu-chih Li*" (note 10).

148. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 77 (note 80).

149. For details, see Arthur Beer et al., "An 8th-Century Meridian Line: I-Hsing's Chain of Gnomons and the Pre-history of the Metric System," *Vistas in Astronomy* 4 (1961): 3–28.

150. Translated by Beer et al., "Meridian Line," 10 (note 149).

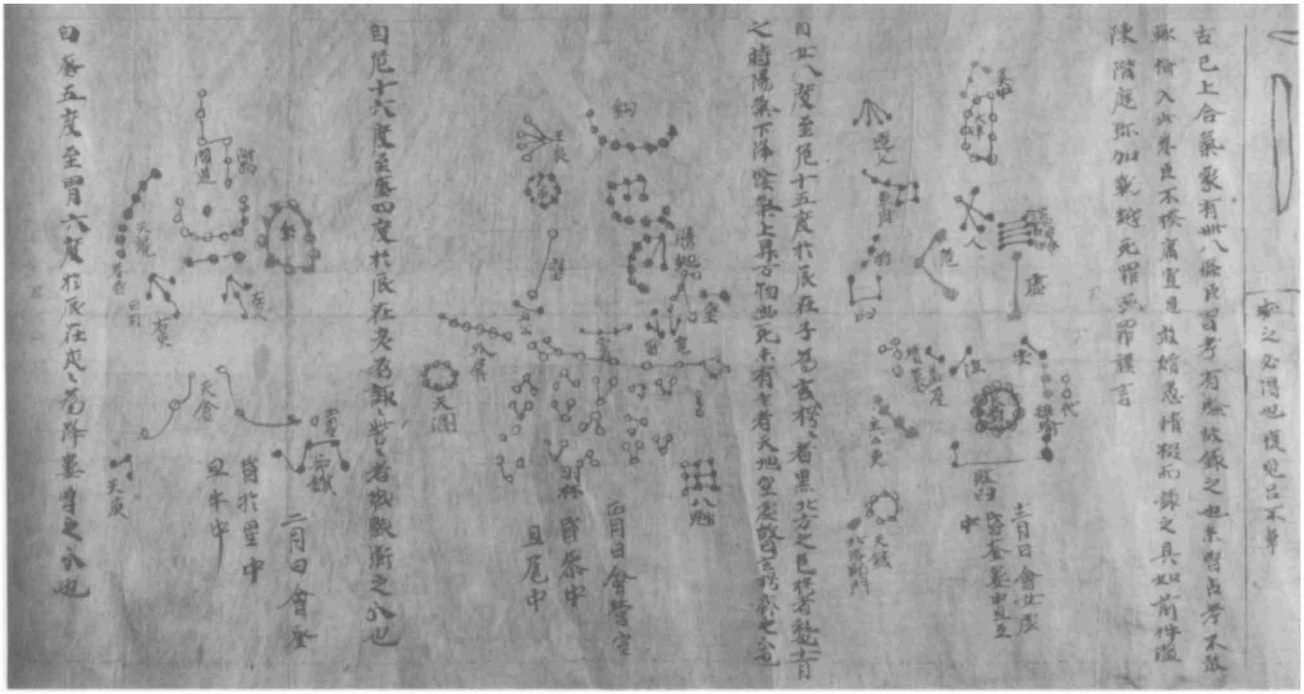


FIG. 13.7. DUNHUANG STAR MAP IN THE BRITISH LIBRARY. The map is illustrated here in four overlapping sections (see also figs. 13.8–13.10); each section reads right to left. Constellations outside the north circumpolar region are depicted. Following the depiction of the region of constant visibility, each vertical strip covers one of the twelve Jupiter stations. There is no attempt at a projection on this rather crude chart.
Size of the entire scroll: 24.5 × 340 cm. By permission of the Oriental and India Office Collections, British Library, London (Stein no. 3326).

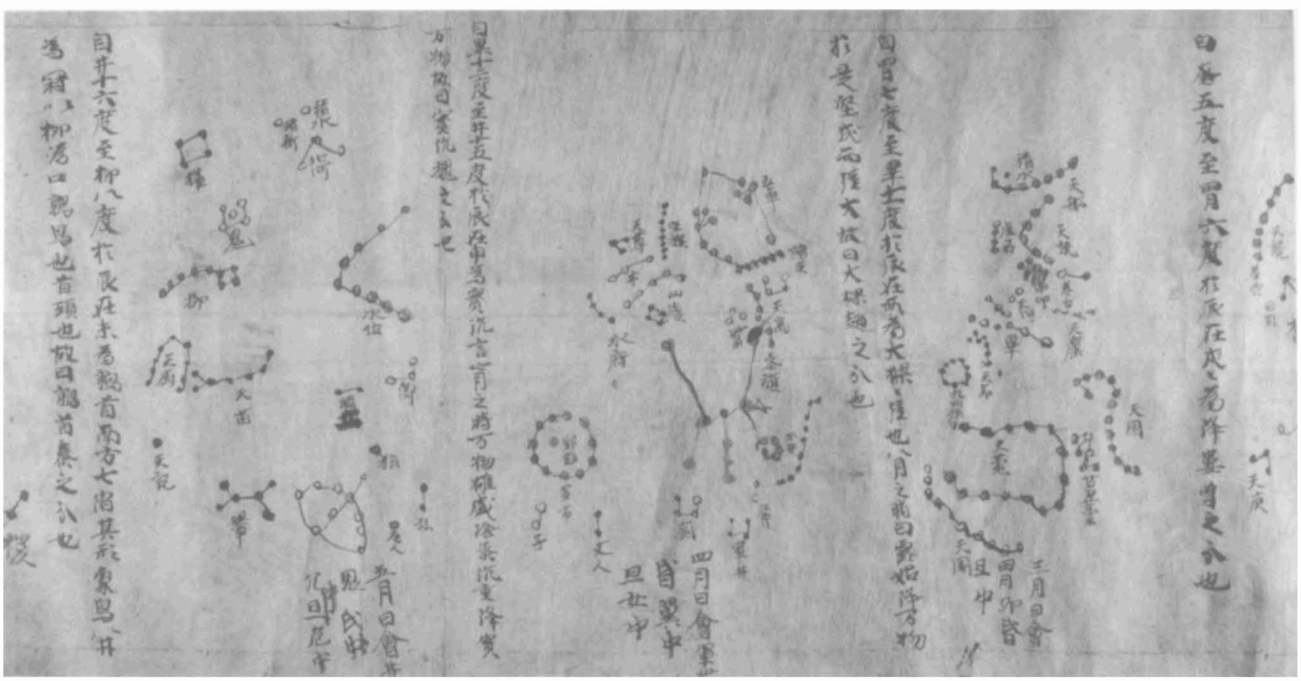


FIG. 13.8. CONTINUATION OF FIGURE 13.7. This continuation toward the east covers about ninety degrees in right ascension, apart from overlap. The band of stars at the right includes both Mao (the Pleiades) and Bi (the Hyades) in Taurus, while the central zone includes Shen (the principal stars of Orion). Note the "bow and arrow" formation in the left band pointing at Lang—the Celestial Wolf (bright star Sirius).
By permission of the Oriental and India Office Collections, British Library, London (Stein no. 3326).

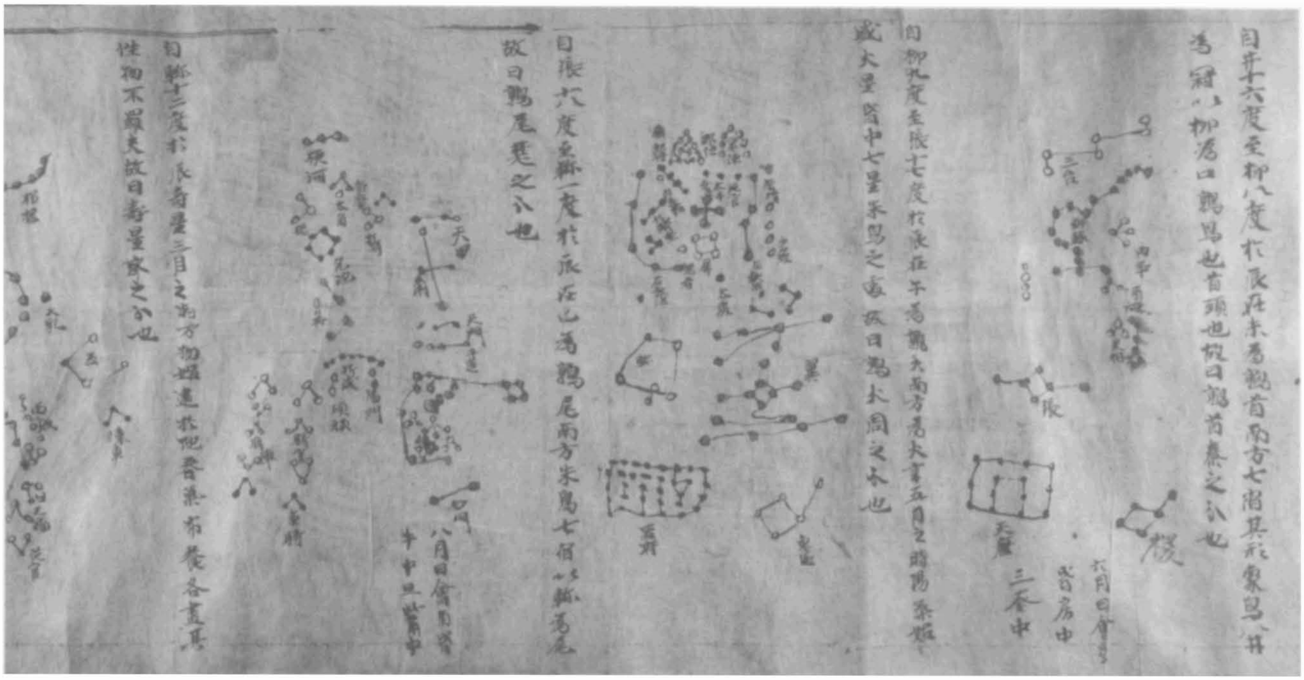


FIG. 13.9. CONTINUATION OF FIGURE 13.8. Continuing toward the east, this section also covers about ninety degrees in right ascension, apart from overlap. The vertical text to the right in this and the other sections gives, among other details, the range of RA (relative to the lunar lodges) within which the stars depicted lie.

By permission of the Oriental and India Office Collections, British Library, London (Stein no. 3326).

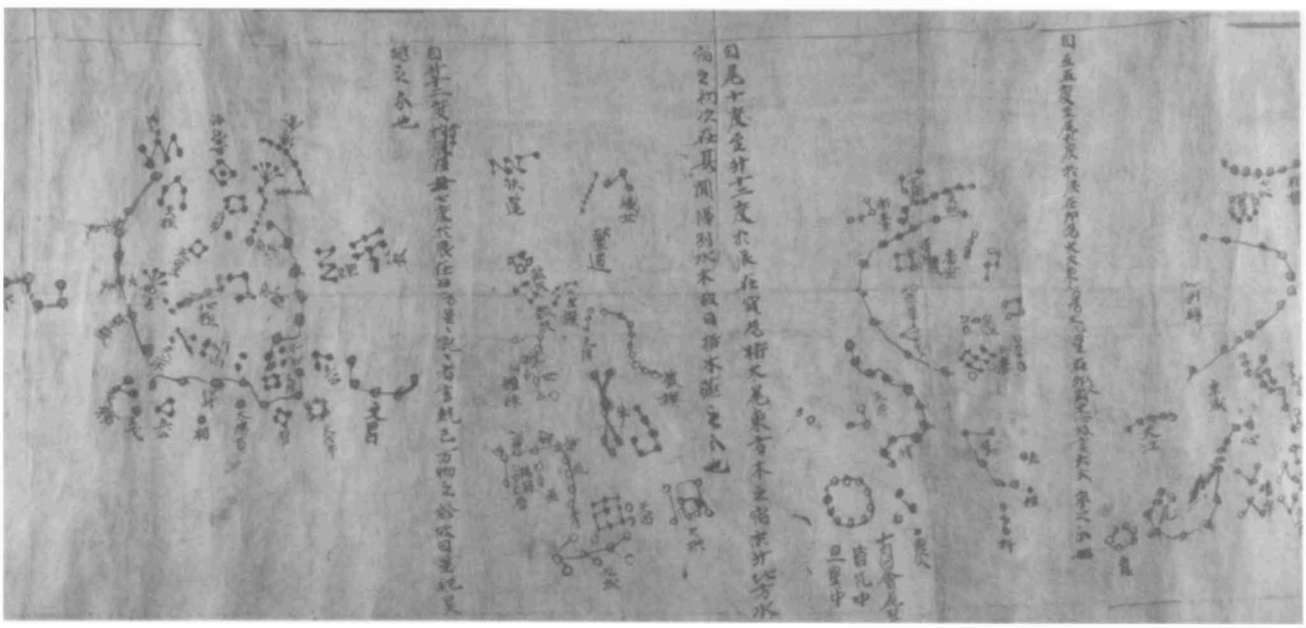


FIG. 13.10. CONTINUATION OF FIGURE 13.9. The three zones toward the right and center are a continuation of figure 13.9 toward the east, thus completing the full circuit of the sky apart from the circumpolar region. The left zone shows the north circumpolar region with the seven stars of Beidou (the Dipper) prominent at the lower edge.

By permission of the Oriental and India Office Collections, British Library, London (Stein no. 3326).

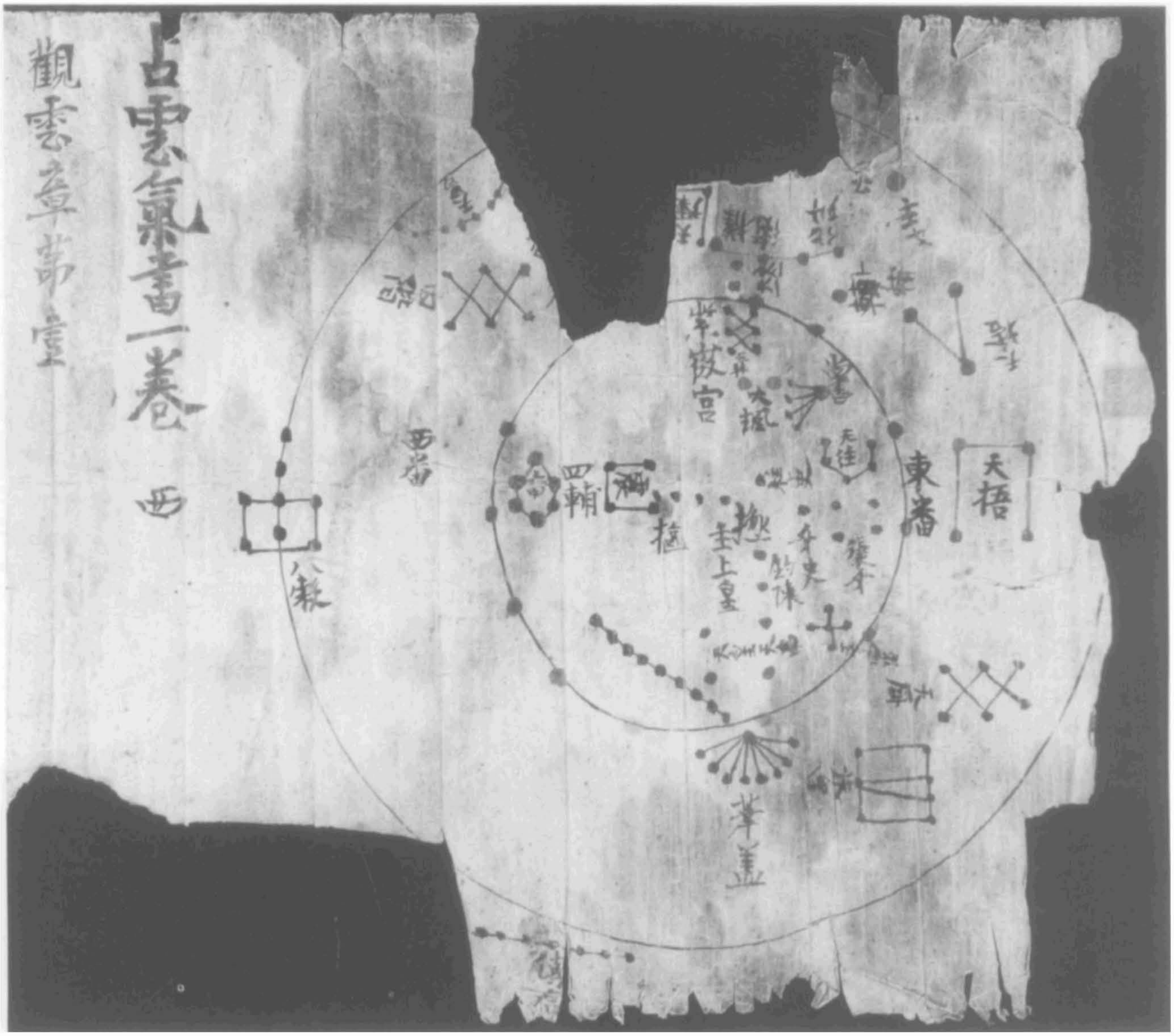


FIG. 13.11. DUNHUANG STAR MAP IN DUNHUANG (NORTH POLAR REGION). Constellations in the north circumpolar region are depicted on this fragmentary paper star map. The two circles are very approximately at declinations +50° and +70°.

Size of the original: unknown. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo (Archaeological Research Institute, Chinese Academy of Social Science [Academia Sinica]), *Zhongguo gudai tianwen wenwu tuji* (Album of ancient Chinese astronomical relics) (Beijing: Wenwu Chubanshe, 1980), 12.

Two fairly detailed star maps that probably date from either the Tang dynasty or the Five Dynasties period (907–60) were discovered in the grottoes at Dunhuang early in the present century. The more substantial of these was among the manuscripts Stein acquired for the British Museum in 1907. A second manuscript astral chart was recovered by Chinese government personnel a few years later (after the European expeditions). It is now preserved in Dunhuang.

The map Stein acquired for the British Museum was first discussed by Needham, who also published photographs of portions of the chart.[151] Needham suggested a date of approximately 940, but he gave no justification for this assumption. However, Chinese scholars tend to prefer a date about two centuries earlier.[152] What little evidence there is seems inconclusive. Of the manuscripts Stein recovered from Dunhuang that bear a date, the earliest was written in 405, and the latest was produced in 995.[153]

151. Stein no. 3326 (this manuscript is now in the British Library); Needham, *Science and Civilisation*, 3:264 and pls. 24 and 25 (note 5).

152. Xi Zezong, "Chinese Studies in the History of Astronomy, 1949–1979," *Isis* 72 (1981): 456–70, esp. 464; Pan, *Zhongguo hengxing guance shi*, 156 (note 7).

153. Lionel Giles, *Descriptive Catalogue of the Chinese Manuscripts*

This crude but colorful chart is depicted on a scroll of buff paper 24.5 centimeters wide (figs. 13.7 to 13.10). In the British Museum catalog, the manuscript is described as of "mediocre" quality.[154] Only the last third of the scroll, whose full length is some 3.4 meters, is devoted to the stellar map. In the earlier portion, various forms of "celestial vapors" are illustrated. The star chart is in thirteen sections. One of these shows the region of constant visibility (north of about declination +55°), and the other twelve depict the remaining portion of the sky visible from China. Each of these latter rectangular strips, approximately thirty degrees wide, covers one of the twelve *ci* (Jupiter stations). There is no attempt at a projection as such; the horizontal (RA) scale is significantly exaggerated relative to the vertical (declination) scale.

Stars are represented on this map by circles of three colors—red, black, and yellow—all constituents of any one asterism being shown by a single color. (These are the same colors mentioned on the Pelliot manuscript from Dunhuang, dated 621.) The various constellations are only roughly sketched, with little or no measurement, and the boundaries of the lunar lodges, celestial equator, and so forth, are not shown. But the name of each star group is marked, and the shapes of the various asterisms resemble those on later maps. As yet, no count appears to have been made of the numbers of constellations and stars that the Dunhuang chart displays. One of the main attractions of the map is its age. It is probably the oldest original representation of the whole of the visible night sky that is still extant from any civilization.[155]

The celestial map that still remains in Dunhuang is in fragmentary condition and covers only the polar constellations (fig. 13.11). The stars are shown in two colors—black and red—on a rather stained buff manuscript. Stellar positions are more carefully marked than on the British Museum map, and two circles of declination are shown. Pan is of the opinion that this is a late copy of a seventh-century map.[156]

A Tang illustration of the twenty-eight *xiu* star groups, painted on the ceiling of a tomb at Asitana in Turpan, was discovered in 1964 (fig. 13.12).[157] The constellation patterns, which are highly idealized, are arranged in a square formation, seven to a side; each edge of the square corresponds to one of the four nonpolar palaces (*gong*). There is no attempt to indicate the irregular spacing of the lunar lodges. Also of Tang origin is a bronze mirror in the collection of the American Museum of Natural History, New York. On the back of this mirror constellation diagrams of the twenty-eight lunar lodges are shown in a circular pattern.[158] The main importance of these artifacts is that they are the oldest well preserved depictions of the *xiu* star configurations as an entity; earlier representations (e.g., of Han origin) have suffered much with the passage of time.

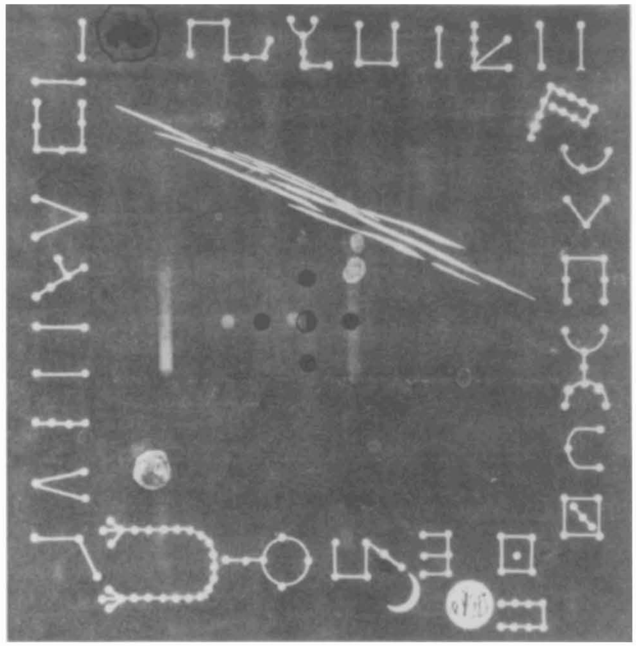


FIG. 13.12. LUNAR LODGE PATTERNS PAINTED ON THE CEILING OF A TANG DYNASTY TOMB AT ASITANA, TURPAN (XINJIANG PROVINCE). The lunar lodges are shown highly idealized, seven to each side of a square. Each group of seven corresponds to one of the four nonpolar palaces (*gong*) associated with the four cardinal directions.
Size of the original: unknown. Xinjiang Uygur Autonomous Regional Museum, Ürümqi. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo (Archaeological Research Institute, Chinese Academy of Social Science [Academia Sinica]), *Zhongguo gudai tianwen wenwu tuji* (Album of ancient Chinese astronomical relics) (Beijing: Wenwu Chubanshe, 1980), 69.

Two catalogs of the constellations are preserved from the early Tang (ca. 635), but these are devoid of positional measurements; they consist merely of qualitative descriptions of some 250 asterisms. The catalogs, which resemble one another closely, are contained in the astronomical

from Tunhuang in the British Museum (London: British Museum, 1957), xi.

154. Giles, *Descriptive Catalogue*, 225 (note 153).

155. Xi Zezong, "Dunhuang xingtu" (A star map from Dunhuang), *Wenwu*, 1966, no. 3:27–38 provides a complete illustration and detailed discussion of the map.

156. Pan, *Zhongguo hengxing guance shi*, 156 (note 7). An excellent color illustration of the Dunhuang map has been published in *Zhongguo gudai tianwen wenwu tuji*, 12 (note 6).

157. See Xinjiang Weiwuer Zizhiqu Bowuguan (Museum of the Xinjiang Uygur Autonomous Region), "Tulufan xian Asitana-Halahezhuo gu muqun fajue jianbao" (Preliminary report on the excavation of ancient tombs at Asitana and Halahezhuo, Turpan County), *Wenwu*, 1973, no. 10:7–27, esp. 18–19; also Schafer, *Pacing the Void*, 79–81 (note 12).

158. For a discussion and photograph, see Edouard Chavannes, "Le cycle turc des douze animaux," *T'oung Pao*, 2d ser., 7 (1906): 51–122.

treatises of the *Jin shu* (chap. 11) and *Sui shu* (chaps. 19–20).[159] Both were compiled by the Tang astronomer royal Li Chunfeng (602–70) as supplements to the records of celestial events in the dynasties covered by the histories. A count indicates 240 asterisms containing 1,298 stars in the *Jin shu* list.[160] The *Sui shu* catalog includes a few asterisms not found in the *Jin shu*.

The *Jin shu* and *Sui shu* star catalogs specify the number of stars in each asterism they cite, but the descriptions of relative position of the various constellations are vague. For instance, they would be of less help than the *Butian ge* poem (see above) as a guide to the night sky. Their main use is as astrological manuals, and in this regard they are extremely comprehensive.

An interesting description of the Milky Way is given at the end of the Jin and Sui catalogs. This detailed account, which traces the path of the River of Heaven across the sky from Scorpio, northward to Cassiopeia, and then southward to Vela, is worth quoting in full:

> The River of Heaven rises up in the east and passes between Wei (6th lunar lodge) and Ji (7th lunar lodge) known by the name Hanjin ("Ford of the Heavenly River"). There the River divides into two branches (which follow different routes).
>
> The southern (route) passes (the constellations) Fuyue, Yu, Tianyo, Tianbian and Hegu. The northern (route) passes below (the stars of) Gui, penetrates beneath Ji (7th lunar lodge) and connects together the head of Nandou (8th lunar lodge) and Zuoqi. After passing below Tianjin, it rejoins the southern branch, and the two travel together in a southwesterly direction.
>
> (The River of Heaven) then encloses Hugua, and joins together (the constellations) Ren, Chu, Caofu, Tengshe, Wangliang, Fulu, the northern tip of Gedao, Tailing, Tianchuan and Juanshe. From there it travels southwards and encloses Wuche. Then it passes through the south of Beihi, enters Dongjing (22nd lunar lodge) and Shuiwei, and takes a south-easterly direction. After connecting (the constellations) Nanhe, Quejiu, Tiangou, Tianji ("Celestial Cycle") and Tianji ("Celestial Pannicled Millet"), it finally declines in the heavens south of Qixing (25th lunar lodge).[161]

This is probably the earliest detailed account from any part of the world of the circuit of the Milky Way.

Yixing and his colleagues made a number of accurate determinations of star positions, including a series of measurements of the NPDs of the determinative stars of the lunar lodges in 725. These latter data are preserved in the astronomical treatises of both the *Jiu Tang shu* and the *Xin Tang shu*, where they are compared with Han results. Most of the measurements Yixing made are expressed to the nearest degree, although a few are given to the nearest half degree. Analysis of these data indicates a typical error of rather less than a degree.[162] Yixing also made a number of determinations of the ecliptic latitudes of certain stars, noting that they appeared to have changed since Han times. His supposed variations are much too large to be explained by proper motion, however; they must merely result from errors of measurement and poor definition of the ecliptic.[163]

One of the most interesting—and valuable—of all Tang astronomical records is a careful account of the path of Halley's comet through the constellations in the spring of 837. At that time the comet was making its closest known approach to the earth (some twelve times the lunar distance) in the entire historical period. Since the motion of the comet was considerably perturbed by its near encounter with our planet, the remarkably precise Chinese observations have proved of great value to modern astronomers in investigating the past orbit.[164] The text in the astronomical treatise of the *Jiu Tang shu* is too long to translate here,[165] but on approximately ten separate nights the comet's RA (expressed relative to the lunar lodges) was measured to the nearest degree and sometimes half degree. At about its closest approach to the earth, it was traversing the sky at more than forty degrees daily. The Tang record is so precise that it enables the date and time of perihelion (when the comet came nearest to the sun) to be deduced to within an hour or so. This account of Halley's comet is by far the most extensive and accurate record of the motion of a comet from any part of the world before the European Renaissance.

As I noted in the previous section, a Sui translation of an Indian Buddhist sutra contains the oldest known Chinese references to the twelve signs of the Western zodiac. Tang translations of further Buddhist scriptures, including the sutra known as *Xiu yao jing* (Lunar lodges and planets), dating from 760, make further references

159. The *Jin shu* star catalog has been translated by Ho, *Astronomical Chapters*, 67–112 (note 4), as part of his translation of the entire astronomical treatise of the *Jin shu*. This excellent translation has been referred to several times in this chapter. No other astronomical treatise in the standard dynastic histories from the Han to the Ming has so far been translated in extenso into a Western language.

160. Ho, *Astronomical Chapters*, 19 (note 4).

161. Translated by Ho, *Astronomical Chapters*, 112–13 (note 4).

162. This result is based on my unpublished analysis.

163. Xi Zezong, "Seng Yixing guance hengxing weizhi di gongzuo" (On the observations of star positions by the priest Yixing [683–729]), *Tianwen Xuebao* 4 (1956): 212–18, esp. 212; Ang Tian Se, "I-Hsing (683–727 A.D.): His Life and Scientific Work" (Ph.D. diss., University of Malaya, Kuala Lumpur, 1979), 378–85.

164. See, for example, Donald K. Yeomans and Tao Kiang, "The Long-Term Motion of Comet Halley," *Monthly Notices of the Royal Astronomical Society* 197 (1981): 633–46.

165. A complete translation, with commentary, is given by Stephenson and Yau, "Far Eastern Observations," 206–7 (note 2).

to the zodiac.[166] Although by the Tang most of the Chinese names of the zodiacal signs had remained unchanged, Gemini was now typically identified as a man and a woman, while Virgo had become two women. Capricorn remained the sea monster, under names such as Ma-giat or Ma-kiat—further attempts to transcribe the Sanskrit *makara*. These are the usual equivalents at subsequent periods in Chinese history.

The earliest known pictorial representations of the signs of the zodiac that are of Chinese origin also date from the Tang. These sketches are among the manuscripts recovered from Turpan in 1975.[167] Although now somewhat fragmentary, they depict the symbols for a few of the zodiacal signs. In one example, the symbols for Virgo (two women) and Libra (a balance) are shown alongside drawings of adjacent *xiu* star groups.[168] The contrast between the representations of the Western signs of the zodiac and the Chinese lunar lodges is interesting; the latter are almost invariably indicated by star patterns, scarcely ever pictorial symbols (fig. 13.13). During the latter half of the Tang, horoscope astrology based on the Western zodiac arrived in China. This became fairly widespread at the popular level, especially among Buddhist adherents, but had negligible impact on the official astrology practiced at court.[169]

Little is known regarding celestial cartography during the turbulent Wudai or Five Dynasties period, which lasted from 907 to 960. The brief astronomical treatises in the official dynastic histories—the *Jiu Wudai shi* (Old history of the Five Dynasties) by Xue Juzheng (912–81), chapter 139, and the *Xin Wudai shi* (New history of the Five Dynasties) by Ouyang Xiu (1007–72), chapter 59—make no mention of the production of star maps at this time. Although a significant number of celestial observations (eclipses, lunar and planetary movements, comets, and such) are recorded in these works, positional measurements are rare. Nevertheless, some interesting representations of the lunar lodges are preserved from the time of the Five Dynasties.

Several tombstones of the Southern Tang dynasty (937–60) in Jiangsu Province are engraved with idealized outlines of the twenty-eight *xiu* arranged in sevens along the sides of a square.[170] But the most important finds from the Five Dynasties period show much more careful representations of the lunar lodges. Two maps were discovered at Hangzhou during excavations of the tombs of Qian Yuanguan (who died in 941) and his wife Wu Hanyue (d. 952). Each chart was carved on the stone ceiling of the mausoleum. Qian Yuanguan was ruler of the small state of Wuyue, which existed during the whole of the Five Dynasties period. The first chart was recovered in 1958 from the mausoleum of Wu Hanyue.[171] Further excavations in 1975 led to the recovery of the second chart from the tomb of her husband.[172] The two plani-

FIG. 13.13. FRAGMENTARY TANG SKETCH SHOWING THE WESTERN ZODIACAL SYMBOLS. Symbols of the zodiacal signs Virgo (characteristically shown as two women) and Libra are depicted, as well as the outlines of Chinese lunar lodges on this Buddhist manuscript unearthed at Turpan, Xinjiang Province.

Size of the original: unknown. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 70.

166. *Da zang jing*, section 1299; see Eberhard, "Untersuchungen an astronomischen Texten," 232 ff. (note 144).

167. For details, see Xia Nai, "Cong Xuanhua Liao mu di xingtu lun ershiba xiu he huangdao shier gong" (Discussion of twenty-eight lodges and the twelve palaces on the ecliptic based on a star map from a Liao tomb at Xuanhua), *Kaogu Xuebao*, 1976, no. 2:35–58, esp. 49 ff. Reprinted in *Kaoguxue he keji shi* (Archaeology and the history of technology), by Xia Nai (Beijing: Kexue Chubanshe, 1979), 29–50, esp. 46–47.

168. Photographs are published by Xia, "Cong Xuanhua Liao mu di xingtu lun ershiba xiu he huangdao shier gong," pl. 13 (top) (note 167), and in *Zhongguo gudai tianwen wenwu tuji*, 70 (note 6).

169. For discussions of Tang astrology, see Schafer, *Pacing the Void*, 58–119 (note 12), and Shigeru Nakayama, "Characteristics of Chinese Astrology," *Isis* 57 (1966): 442–54, esp. 450.

170. Photographs are published in *Zhongguo gudai tianwen wenwu tuji*, 75–76 (note 6).

171. For details, see Zhejiangsheng Wenwu Guanli Weiyuanhui (Committee for the Management of Cultural Relics, Zhejiang Province), "Hangzhou Lin'an wudai muzhong di tianwen tu he mise ci" (Astronomical maps and specially glazed porcelains found in the Five Dynasties tombs at Hangzhou and Lin'an), *Kaogu*, 1975, no. 3:186–94, esp. 190–91; a scale drawing is provided (the stele is no longer extant).

172. Yi Shitong, "Zuigu di shike xingtu—Hangzhou Wuyue mu shike xingtu pingjia" (The oldest star map engraved in stone—An assessment of a star map engraved on stone from the Wuyue tomb at Hangzhou), *Kaogu*, 1975, no. 3:153–57. Both a photograph of a rubbing and a scale drawing are shown in this article. The stele is damaged, but its surface is in fair condition. It measures about 4.2 by 2.7 meters and is now housed in a huge glass showcase at Hangzhou Beilin (Hangzhou Forest of Steles).

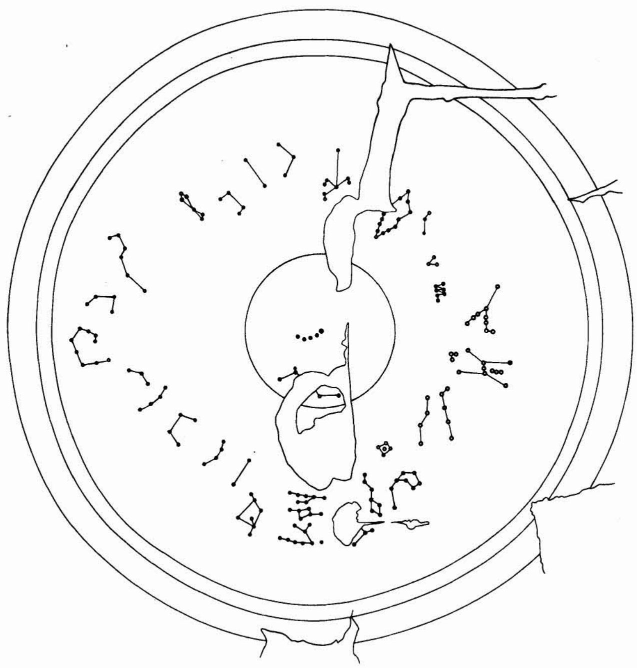


FIG. 13.14. DRAWING OF A WUYUE STAR MAP SHOWING LUNAR LODGES. The stele from which this drawing was made closely resembles that in figure 13.15. It was found in 1958 in the tomb of Wu Hanyue but is said to have been destroyed during the Cultural Revolution. Fortunately, this accurate scale drawing survives.
Diameter of the original: 180 cm. Redrawing from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 73.

FIG. 13.15. RUBBING OF A WUYUE STAR MAP ALSO SHOWING LUNAR LODGES. Although badly damaged, the stele from which this rubbing was made shows the lunar lodges and a few polar asterisms with fair precision. It was recovered in 1975 from the tomb of Qian Yuanguan.
Diameter of the original: 190 cm. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 72.

spheres closely resemble one another (figs. 13.14 and 13.15).[173] Both depict only a few constellations: the twenty-eight *xiu* and a few circumpolar asterisms, notably Beidou. The projection is polar (equidistant); in each case the circle of constant visibility is shown, while the boundary of each chart represents the circle of constant invisibility. The celestial equator is also marked on the map that was found in the grave of Qian Yuanguan. Measurements on this chart indicate a circle of constant visibility of radius 37°, while the edge of the chart extends to 38° south of the equator. These correspond better to northern China; the latitude of Hangzhou is close to 30°.

The outlines of the various asterisms on the Wuyue planispheres approximate the true configurations fairly well; typical positional errors are about three degrees. Hence, though only a small number of constellations are displayed, the Qian Yuanguan stele is the oldest known Chinese star map of any precision. An interesting minor feature of both charts is the inclusion of eight stars in Beidou: the seven well-known constituents together with 80 UMa (Alcor), which is situated only eleven arc minutes from the much brighter star η UMa (Mizar). Here we have possibly the earliest known pictorial representation of this rather close binary, regarded by the Arabs as something of a test of sight.

The Song and Contemporary Dynasties (960–1279)

Many celestial charts and globes are known to have been produced during the Song dynasty, and two important products of this period still exist. These are probably the most detailed and accurate maps of the night sky that have come down to us from the whole of the pre-Jesuit period in China. Unlike the star charts that survive from previous dynasties, both Song artifacts are mentioned in the extant literature of their own time, and their history can be traced in detail. One of the charts, engraved on stone in 1247, is still in almost pristine condition, but the other map, though originally produced much earlier (1094), now exists only in late copies. The original version

173. The two charts are illustrated and discussed in *Zhongguo gudai tianwen wenwu tuji*, 72–73 and 122 (note 6).

of this latter work was the first known star chart from any part of the world to be printed. Both Song maps will be discussed in detail later in this section.

Other maps and globes of Song origin that are mentioned in history have long since disappeared. Thus in the late tenth century the *Taiping yulan* (Imperial encyclopedia of the Taiping reign period, compiled 983) notes the existence of a work titled *Liexing tu* (Map of the principal stars) but does not mention the compiler. Later, Ma Yongqing mentions in his *Lanzhen zi* (Book of the truth-through-indolence master) that about 1115 he often discussed astronomy with certain monks who possessed maps of the stars. Not long afterward (ca. 1150), Zheng Qiao (1108–66) in his *Tongzhi* (Comprehensive treatises) complained that printed star charts were generally not to be relied upon and furthermore were hard to correct.[174] The problems of cutting the necessary printing blocks (complete with names of constellations) with adequate precision and producing good-quality impressions from them must have been considerable. Zheng Qiao's remarks suggest that printed maps of the night sky were fairly common by the middle of the twelfth century—several centuries before they first appeared in Europe.

According to the official Song history, the *Song shi*, an instrument that was probably a celestial globe was designed by a student in the official bureau of astronomy at Bian (modern Kaifeng), the Song capital, in 976. This device, which was driven by a water clock, was said to depict "the Purple Palace, the lunar lodges in order, Beidou, and the celestial equator and ecliptic."[175] No further information is given concerning the number of asterisms or stars represented. It is not known how long the globe remained in use.

In chapter 80 of the *Song shi*, under a year corresponding to 1102, we find the following account by a government minister named Wang Fu:

> I chanced to meet a wandering unworldly scholar at the capital, who told me his family name was Wang and gave me a Daoist book which discussed the construction of astronomical instruments in detail. So afterwards I asked the emperor to order the Supply Department to make some models to test what it said. This they did in the space of two months. The instrument is round like a ball, graduated in 365¼ degrees, and shows the south and north poles . . . the ecliptic and equator, . . . the twenty-eight lunar lodges, the three walled regions of the heavens, and the stars of the whole heavenly round.[176]

In the quotation above, the "three walled regions" are the Ziwei *yuan*, Taiwei *yuan*, and Tianshi *yuan*. It is regrettable that information on the representation of the constellations on this celestial globe is so brief. The fate of this artifact is not known.

Not long before—in 1092—the great astronomer Su Song (1020–1101) had, on imperial command, constructed an armillary sphere and a celestial globe. These instruments were installed in a tower at Bian and were driven by a water clock employing an escapement device.[177] They were said to accurately replicate the apparent motion of the heavens. In his *Xinyi xiang fayao* (New design for an armillary [sphere] and [celestial] globe), printed in 1094, Su Song gives the following description of the celestial globe:

> The body of the celestial globe is spherical like a ball and has a diameter of 4.565 [*chi*] [some 1.7 m]. On its surface, the circumference is marked with 365 and a fraction degrees [*du*], and the constellations and stars both north and south of the equator are marked; there being 246 names (of constellations) and a total of 1281 stars. The [Purple Palace] is situated at the northern part with thirty-seven names of groups and a total of 183 stars. The sum total is therefore 1464 stars. It (the globe) is circumscribed by the ecliptic and equator. The twenty-eight lunar lodges are shown in their succession, and also the path where the sun, moon and five planets move.[178]

The total number of both constellations (283) and stars (1,464) said to be depicted follows the traditional figures of antiquity.[179] Sadly, the celestial globe and other instruments constructed by Su Song did not remain in operation long. In 1126 the emperor and his court abandoned Bian to the invading Jin armies, later establishing a new capital at Lin'an (modern Hangzhou) in the south. Chapter 22 of the *Jin shi* (History of the Jin, 1345) relates that "all the astronomical instruments were carried away [by the Jins] in carts to Yen [near modern Beijing]. The [various gear wheels], the celestial globe, the bells, . . . all broke or wore out after some years. Only the bronze armillary sphere remained in the observatory of the (Jin) Bureau of Astronomy and Calendar."[180]

Fortunately, star maps that may closely follow the

174. These references to Song star charts that are no longer extant are from Needham, *Science and Civilisation*, 3:281 (note 5).

175. Tuotuo et al., *Song shi* (History of the Song, 1346), chap. 38; see the modern edition in 40 vols. (Beijing: Zhonghua Shuju, 1977). See also Needham, Wang, and Price, *Heavenly Clockwork*, 71–72 (note 80).

176. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 119–20 (note 80).

177. A detailed description of the construction of the clock tower and its instruments is given by Needham, Wang, and Price, *Heavenly Clockwork*, chaps. 4–6 (note 80).

178. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 46 (note 80).

179. For example, the star map produced by Chen Zhuo during the third century A.D. was said to depict precisely these numbers of asterisms and stars—see above.

180. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 132 (note 80).

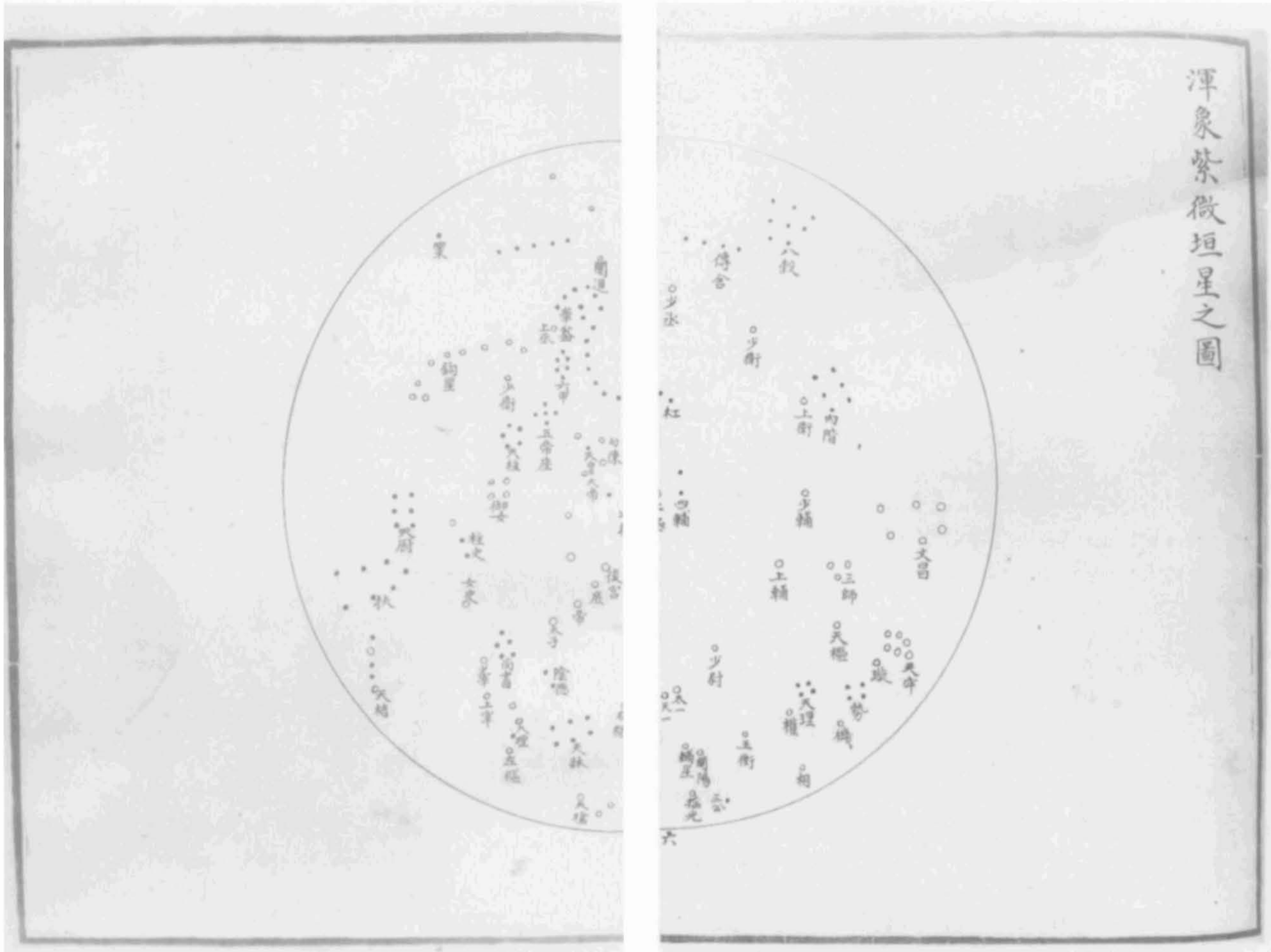


FIG. 13.16. THE SU SONG STAR MAP OF THE NORTH POLAR REGION. Thirty-seven star groups containing 174 stars are depicted in this chart of the north circumpolar region (north of declination +58°). The chart shown here and those in figures 13.16 to 13.20 originally date from 1094 and were the earliest printed star maps. The originals have long since been lost, and the figures here are from the 1781 edition of *Xinyi xiang fayao* said to be based on an 1172 manuscript.
Size of each page: 30 × 22 cm. By permission of the National Library of China, Beijing.

uranography on Su Song's celestial globe are still extant in copies of his *Xinyi xiang fayao*.[181] Today the earliest extant version dates from 1781 and is preserved in the National Library, Beijing. It is said to be based on a careful manuscript copy of an 1172 printing made about 1670 by the bibliophile Qian Zeng, which took several months to complete. The following details are recorded in the *Siku quanshu* (Complete library from the four treasures), a catalog of rare books compiled 1773–82:

> After the Southern Song (period), there were only very few copies of this book remaining. The edition we now have follows the text of that in the possession of Qian Zeng of the Ming dynasty. At the back of this book there were the two following lines, "Edition of . . . the 8th year of the Qiandao reign-period (A.D. 1172)." This shows that the present edition is a true copy of the text of the Song edition. . . . the copying of Qian Zeng was extremely skilful. . . . He himself said that "all the illustrations with their lines and details (followed the original copy) without a hair's-breadth of difference. . . . The result was in no way inferior to the Song edition itself."[182]

In the *Xinyi xiang fayao* the night sky is divided into five sections as follows: (1) the north circumpolar region (north of about declination +58°) (fig. 13.16); (2) stars between RA 12 hours and 24 hours (from the autumn to the spring equinoxes) and in the approximate declination range −58° to +58° (fig. 13.17); (3) stars between RA 0 hours and 12 hours and in the same declination range as (2) (fig. 13.18); (4) the entire Northern Hemi-

181. See *Zhongguo gudai tianwen wenwu tuji*, 77–81 and 122–23 (note 6).

182. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 12 (note 80).

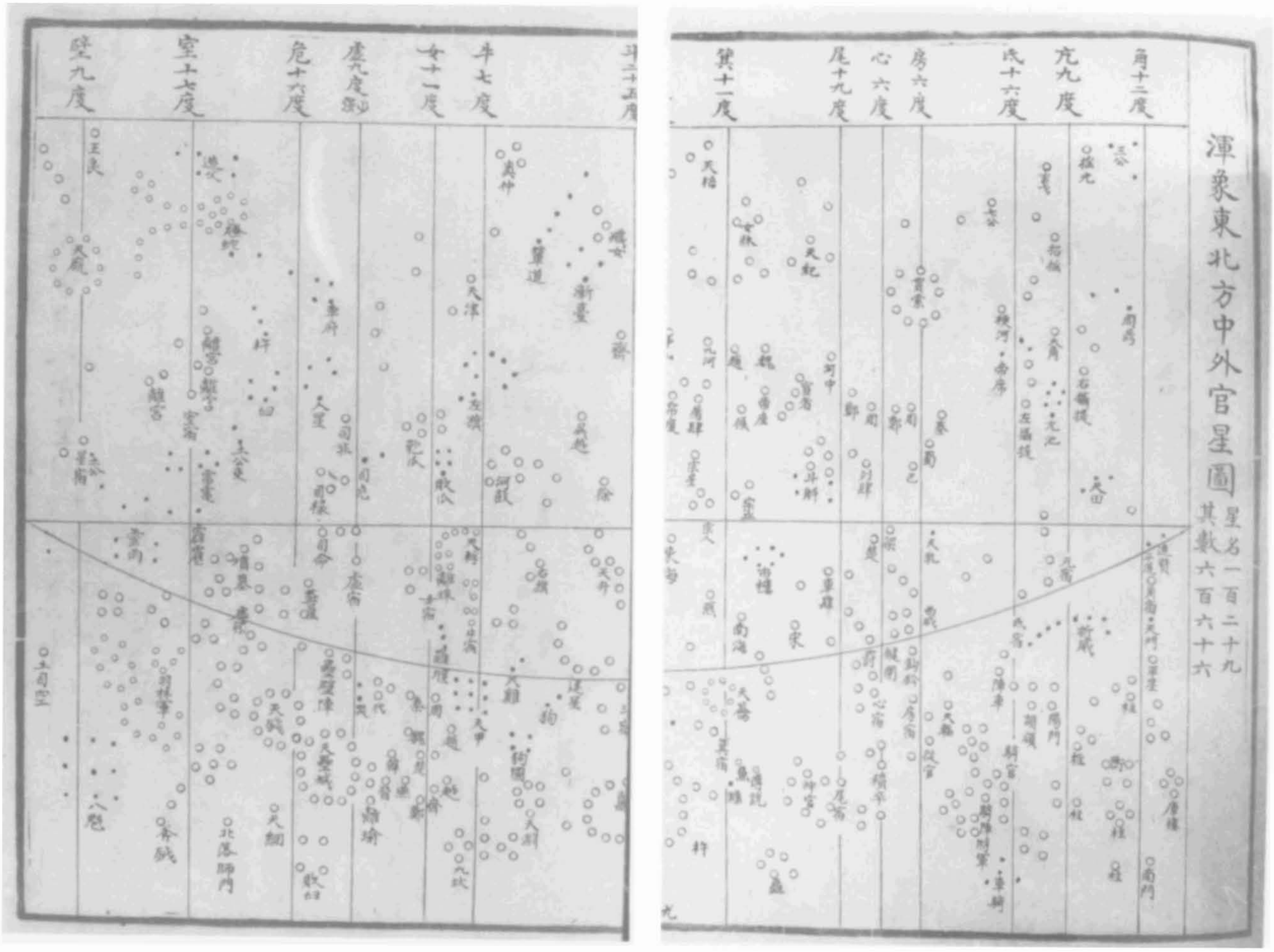


FIG. 13.17. THE SU SONG STAR MAP FROM 12 HOURS TO 24 HOURS RA. A total of 666 stars and 129 asterisms are said to be shown in this chart of the nonpolar regions between RA 12 hours and 24 hours. Boundaries of the lunar lodges are represented by vertical straight lines; the equator and ecliptic are also shown.
Size of each page: 30 × 22 cm. By permission of the National Library of China, Beijing.

sphere (fig. 13.19); and (5) the Southern Hemisphere down to the circle of constant invisibility (approximate declination −58°) (fig. 13.20). For comparison, the colatitude of Kaifeng is close to 55°.[183]

Charts 1, 4, and 5 (figs. 13.16, 13.19, and 13.20), which are circular, are on a polar (equidistant) projection, map 5 having a central void representing the region of sky permanently below the horizon. The remaining maps, which are rectangular, do not use a true projection but employ roughly equal scales for RA and declination. Needham's allusion to these charts as being on "Mercator's" projection has thus led several unwary authors astray.[184] On maps 2 and 3 (figs. 13.17 and 13.18) the boundaries of the lunar lodges are indicated by parallel lines, while on charts 4 and 5 the *xiu* limits are depicted by radial lines extending from the celestial equator to either the circle of constant visibility or the edge of the zone of constant invisibility. Both the ecliptic and the equator are indicated on charts 2 and 3, but the Milky Way is omitted. Constellations and certain stars are individually named on each chart.

The caption to chart 2 states that a total of 117 asterisms and 615 stars are represented thereon, while the corresponding figures for chart 3 are 129 asterisms and 666 stars. The totals of 246 constellations and 1,281 stars are precisely the numbers said to have been represented on the celestial globe of Su Song. A count I have made on chart 1 indicates 37 star groups and 174 stars in the north circumpolar region; the number of constellations

183. The declinations of the circles of constant visibility and constant invisibility for any given station are—ignoring refraction—numerically equal to the colatitude (90° minus the latitude) of that place.

184. Needham, *Science and Civilisation*, 3:278 and fig. 104 (note 5).

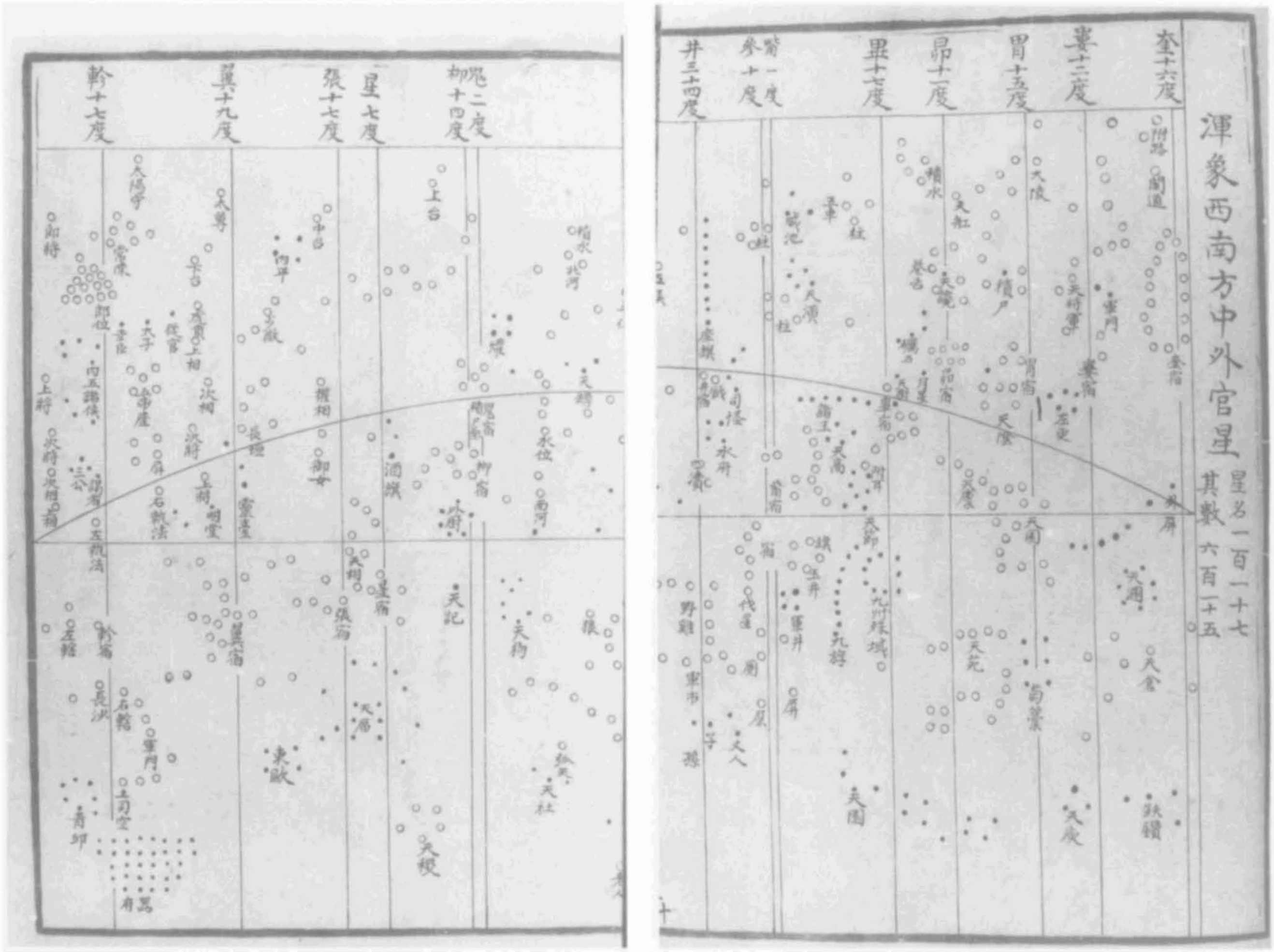


FIG. 13.18. THE SU SONG STAR MAP FROM 0 HOURS TO 12 HOURS RA. A total of 615 stars in 117 asterisms are said to be shown in this chart of the non-polar regions between RA 0 hours and 12 hours. *Xiu* boundaries, equator, and ecliptic are also depicted.

Size of each page: 30 × 22 cm. By permission of the National Library of China, Beijing.

(283) thus agrees with that on the celestial globe for the same region of sky, although there is a slight discrepancy in the star numbers (1,455, compared with the customary figure of 1,464).

On the Su Song charts, all the stars in any particular constellation are denoted by either open circles or black circles. No attempt is made to distinguish between stars of different brightness, which is essentially true of all pre-Jesuit maps of the night sky. Stars are not shown joined into groups, although their grouping is obvious. (On later versions stars are joined into groups by straight lines.) Each constellation is named, as are certain important individual stars. The distribution of asterisms whose constituents are represented by open circles agrees well with that of the star groups depicted in red or yellow on the somewhat earlier Dunhuang star charts; similarly, the grouping of black circles on the maps in the *Xinyi xiang fayao* corresponds closely to the pattern of black circles on the Dunhuang artifact. It seems highly unlikely that Su Song and his colleagues ever saw or were influenced by the Dunhuang charts. Hence we have an independent recurrence of the ancient tradition of sets of constellation groupings.

On the available printings of the Su Song astral maps, individual asterisms are neatly depicted, and on first impression the charts appear to be skillfully executed. Although the equatorial extensions of individual *xiu* are fairly accurately specified (to the nearest degree) at the upper edges of maps 2 and 3, measurements on the charts themselves indicate several errors of two or three degrees in these quantities. Many asterisms are depicted with an idealized form; circular and oval figures and other sym-

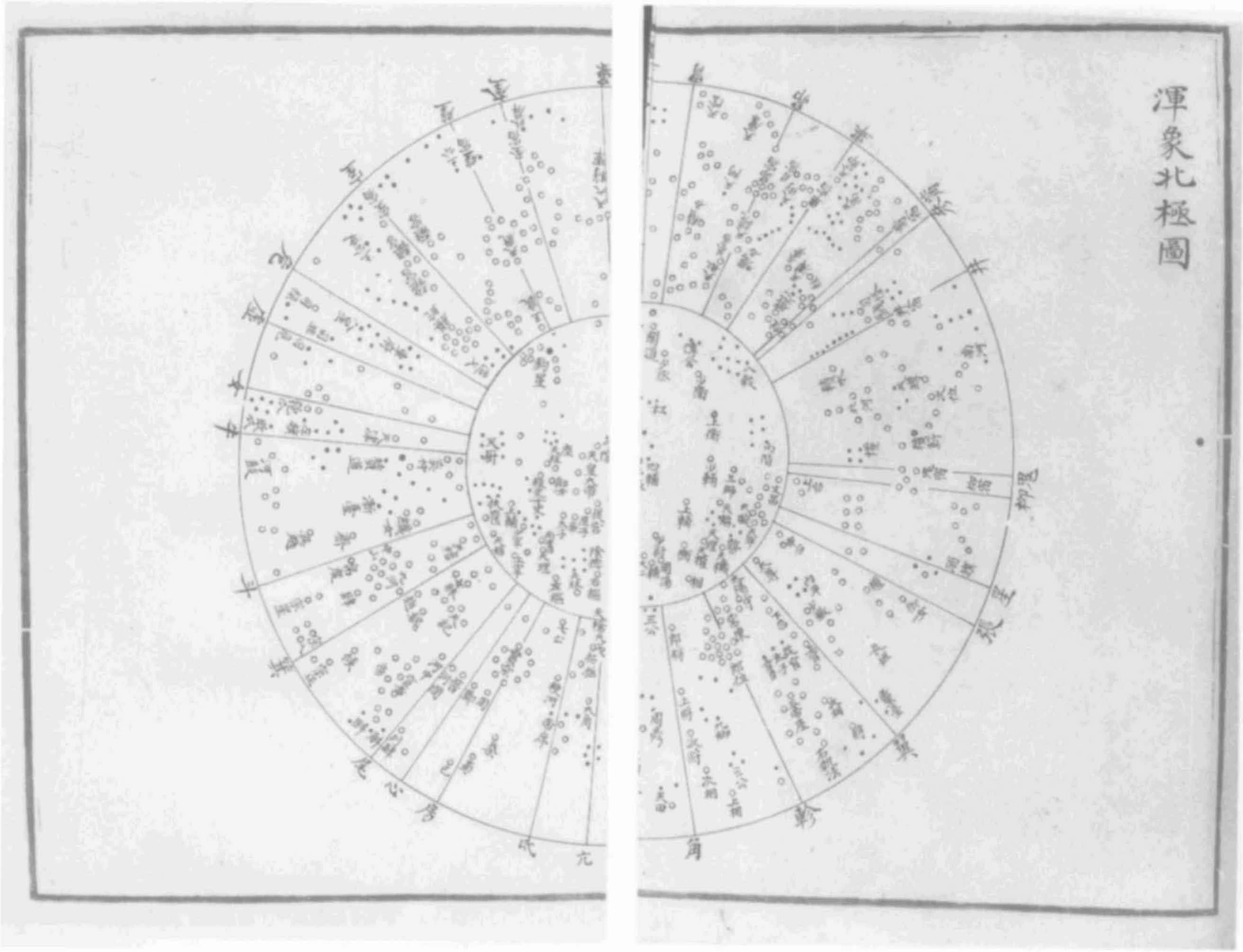


FIG. 13.19. THE SU SONG STAR MAP OF THE NORTHERN HEMISPHERE. Constellations in the entire Northern Hemisphere are depicted. The circle of constant visibility and celestial equator are shown; *xiu* boundaries are represented by radial lines. Size of each page: 30 × 22 cm. By permission of the National Library of China, Beijing.

metrical features are fairly common. An analysis (unpublished) I have made of the locations of a sample of twenty bright stars shows that the mean error in declination is as high as four degrees, some discrepancies exceeding ten degrees. These results recall the complaint of Zheng Qiao that in his time (mid-twelfth century), printed star charts were generally not to be relied on.

A considerably superior star map of Song origin, dating from 1247, is preserved in the collection of the Suzhou (Soochow) Museum in Jiangsu Province, not far from the Southern Song capital of Hangzhou. This planisphere, some 1.05 meters in diameter, is engraved on a stone block measuring approximately 2.2 by 1.1 meters (fig. 13.21). The stele is extremely well preserved, and direct rubbings of its surface can still be purchased in China. The *Tianwen tu* (Astronomical chart), as it is titled, is accompanied by a description summarizing the basic cosmological and astrological knowledge of the time.[185]

Nearly half a century ago, the Suzhou planisphere was extensively studied by Rufus and Tien.[186] A more recent investigation is by Pan.[187] Both the planisphere and the accompanying explanatory text are believed to be the work of Huang Shang, a Confucian scholar, in 1193. At

185. Since the chart was engraved during the Chunyou reign period (1241–52), this map is sometimes referred to by titles such as the *Chunyou tianwen tu* (Astronomical chart of the Chunyou reign period).

186. W. Carl Rufus and Hsing-chih Tien, *The Soochow Astronomical Chart* (Ann Arbor: University of Michigan Press, 1945).

187. Pan Nai, "Suzhou Nan Song tianwentu bei di kaoshi yu pipan" (Examination and critique of a Southern Song astronomical chart on a stone stele at Suzhou), *Kaogu Xuebao*, 1976, no. 1:47–61. See also *Zhongguo gudai tianwen wenwu tuji*, 84–85 and 123 (note 6).

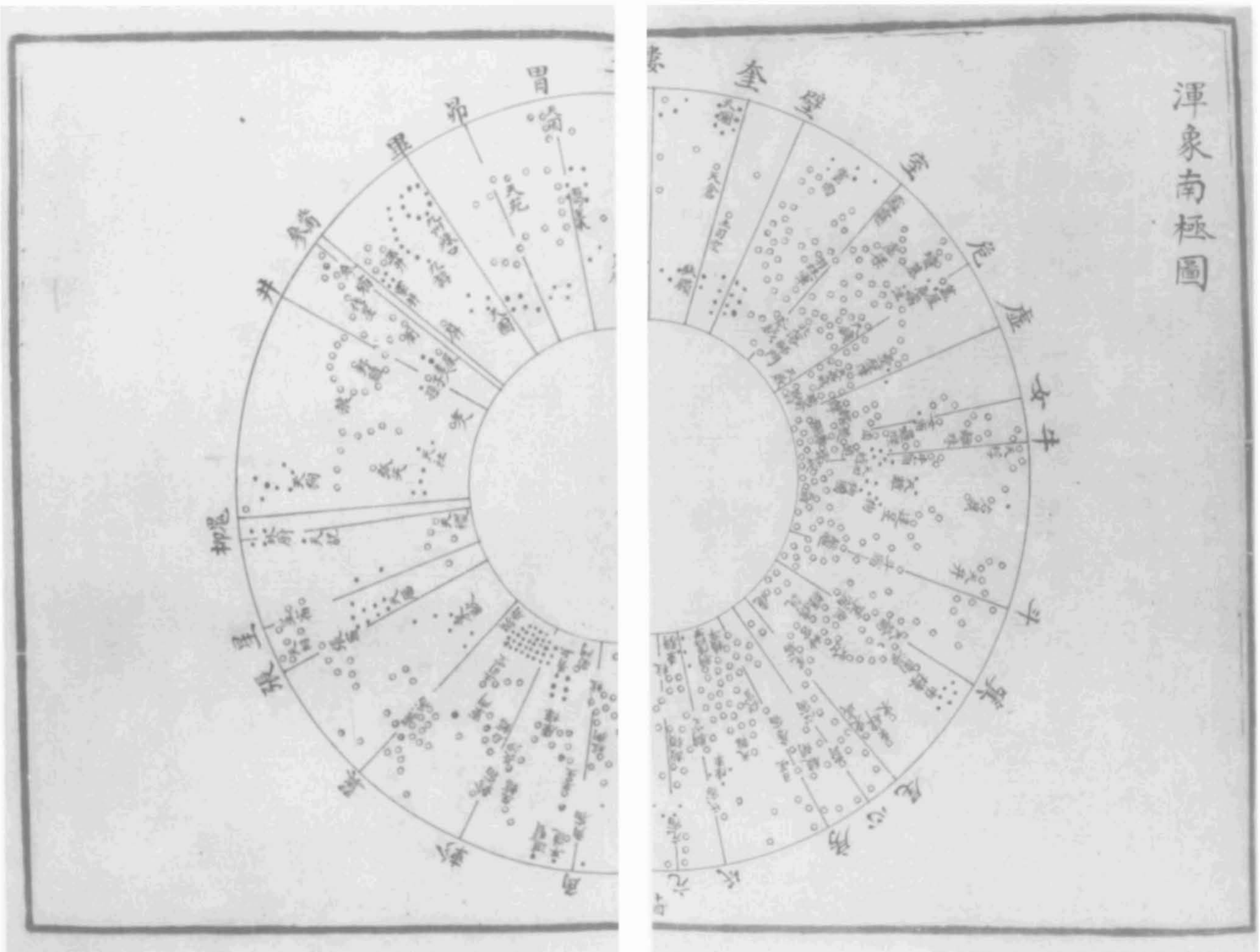


FIG. 13.20. THE SU SONG STAR MAP OF THE SOUTHERN HEMISPHERE. Constellations south of the celestial equator that are visible from China are shown. Between the circle of constant invisibility (declination −58°) and the South Pole, stars are uncharted.

Size of each page: 30 × 22 cm. By permission of the National Library of China, Beijing.

the time, Huang was tutor to Prince Jia, who soon afterward became the emperor Ningzong (r. 1194–1224). Although Huang's work was highly valued, it was not engraved on stone until 1247, more than twenty years after Ningzong's death.

The Suzhou planisphere portrays the whole of the sky visible from central China on a polar (equidistant) projection. The circle of constant visibility (declination +56°), celestial equator, ecliptic (incorrectly represented as a circle), boundaries of the twenty-eight lunar lodges, and outline of the Milky Way are all shown. *Xiu* boundaries are denoted by radial lines extending outward from the circle of constant visibility to the edge of the chart, which represents the circle of constant invisibility (declination −57°). Stars are indicated by small dots, joined into groups by straight lines. A few very bright stars such as Sirius and Canopus are represented by fairly large dots, but no systematic attempt is made to distinguish between stars of different brightness or to divide asterisms into the three ancient sets. Each constellation is named, as are the individual constituents of several important groups. Around the edge of the chart are marked the names and widths of the twenty-eight lunar lodges in *du* (inner circle) and the names of the twelve Jupiter stations, the twelve "terrestrial branches" (*zhi*)—as direction indicators—and other details (outer circle). A count by Rufus and Tien indicated 1,440 stars, and Pan enumerated 1,434. Both totals are rather less than the traditional figure of 1,464. Rufus and Tien noted as many as 313 asterisms—far more than the standard number of 283.[188]

Some idealization in the shapes of the asterisms

188. Rufus and Tien, *Soochow Astronomical Chart* (note 186); Pan, "Suzhou Nan Song tianwentu" (note 187).

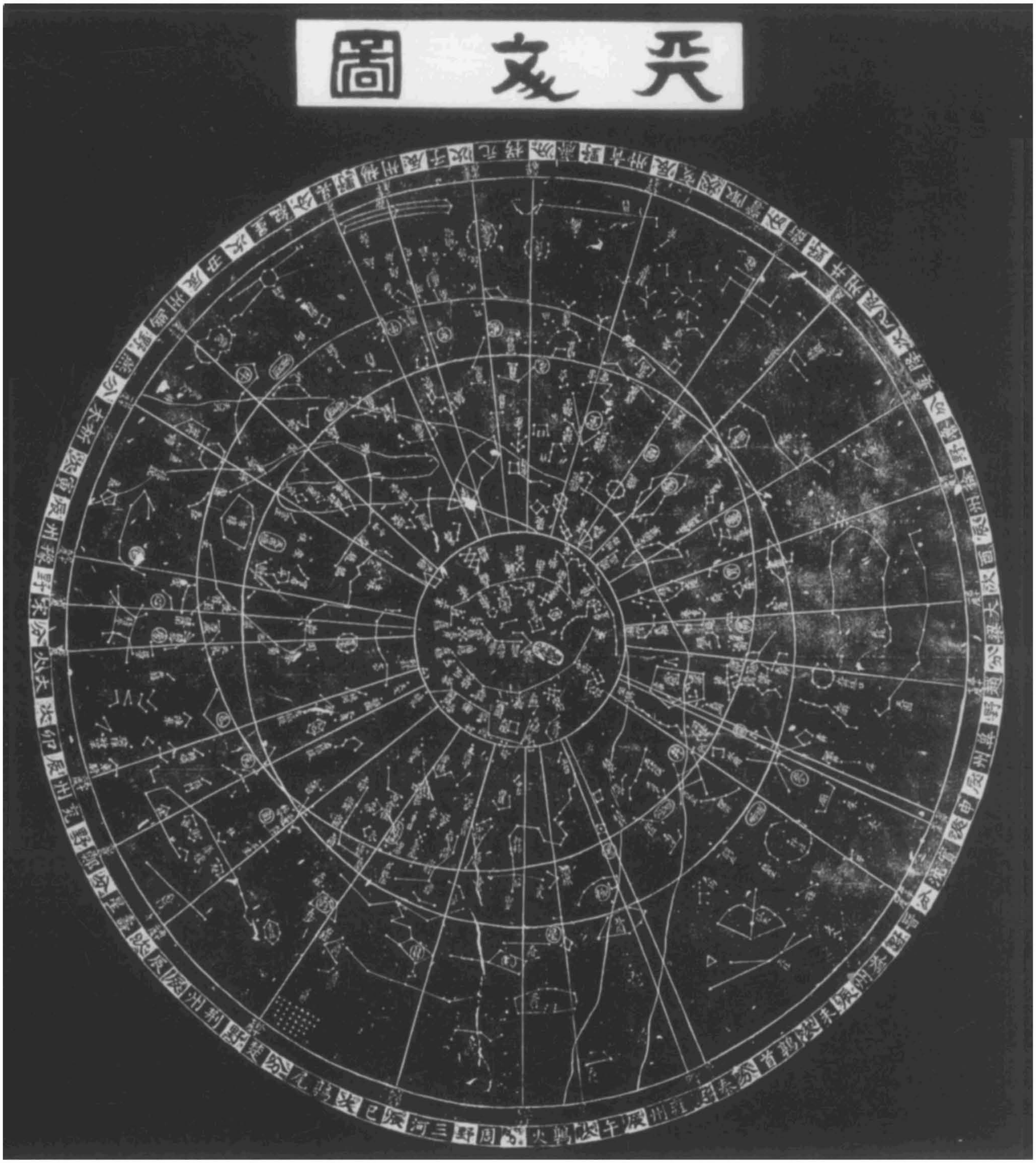


FIG. 13.21. RUBBING OF THE SUZHOU STAR MAP. This detailed star map is estimated to display some 1,440 stars. The projection is polar (equidistant). *Xiu* boundaries are represented by radial lines, and the circle of constant visibility, equator, and ecliptic are shown. The edge of the chart is at −57° declination. Diameter of the original: 105 cm. Suzhou Museum, Jiangsu Province. Photograph from W. Carl Rufus and Tien Hsing-chih, *The Soochow Astronomical Chart* (Ann Arbor: University of Michigan Press, 1945), pl. 1A.

FIG. 13.22. LIAO DYNASTY STAR MAP, 1116. This star map, painted on the ceiling of the tomb of a Buddhist official and excavated at Xuanhua near Beijing, shows all twelve zodiacal symbols (Taurus has since become defaced) as well as the twenty-eight *xiu* constellations.
Diameter of the original: ca. 220 cm. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 13.

depicted on the Suzhou star map can be noticed, but this is less evident than on the charts in the *Xinyi xiang fayao*. A check on the declinations of twenty selected bright stars (as undertaken above for the Su Song maps) reveals a tolerably small average error of less than two degrees. In the sample under discussion, the only really large error was for α Centauri (7.5°), but this may possibly be explained by its proximity to the edge of the map. The widths of the individual *xiu* are accurate to the nearest degree. Judging from this map, celestial cartography had reached a fairly high degree of maturity by the late Song dynasty.

This conclusion is confirmed by a recent analysis of Song determinations of the equatorial extensions of the *xiu* by Guo Shengchi.[189] These widths were measured to the nearest one-quarter *du* by the Northern Song astronomer Yao Shunfu in 1102 and are contained in the calendar treatise of the *Song shi*. In this investigation, Guo showed that typical errors of measurement are as small as about one-quarter degree, superior to the accuracy achieved at any previous period in Chinese history.

After an investigation made by Yabuuchi, Pan and Wang determined the positions of a large number of stars as represented on both the Suzhou planisphere and the *Xinyi xiang fayao* astral charts.[190] They also included a number of observations of star position recorded in the *Wenxian tongkao* (General study of literary remains)—a historical encyclopedia compiled by Ma Duanlin about 1280—and other Song works. As a result, these authors identified as many as 360 stars in terms of their Western equivalents. Before the Song dynasty it is possible to produce a list of concordances in comparable detail only by using the *Xingjing* star list of the Former Han. It is unfortunate that Pan and Wang gave no indication of the confidence (based on an assessment of errors of measurement) with which their identifications could be accepted.

As is evident from the Su Song and Suzhou star charts, very few Chinese asterisms resemble the Occidental constellations. Among larger groups we might cite little more than prominent features of the night sky such as Beidou (already frequently mentioned), Shen (Triad—equivalent to the four principal stars of Orion together with the belt and sword), and Wei (Tail—the tail of the Dragon in Chinese uranography and equivalent to the tail of the Scorpion in the West). On the contrary, the well-known W formation of the bright stars of Cassiopeia is shown divided into two distinct groups on Chinese star maps: Wangliang (named for a famed charioteer of the Zhanguo period) and Gedao (Hanging Gallery). Not surprisingly, the well-defined Pleiades and Hyades clusters in Taurus were recognized as discrete entities in China (under the names Mao and Bi), but it would be difficult to suggest many more examples of correspondence in shape between East Asian and Western asterisms.

Extensive measurements of star positions (not merely confined to the lunar lodges) were carried out several times during the Song dynasty. These surveys took place in the following reign periods: Jingyou (1034–38), Huangyou (1049–54), Xining (1068–77), and Yuanfeng (1078–85). A discussion of the relative precision of some of these measurements is given by Pan.[191] In particular, both the Su Song and Suzhou star maps were based on the results of the Yuanfeng survey.

Not long after the Jin dynasty (1115–1234) was established in northern China, official astronomers began to make observations in the traditional Chinese style. Judging from the quality of many of these observations—as recorded in the astronomical treatise (chap. 20) of the *Jin shi*—it is apparent that the Jin astronomers, like their Song counterparts, were equipped with effective star

189. Guo Shengchi, "Bei Song Heng xing guance jingdu chuyi" (On the accuracy of observations of the North Star during the Northern Song), *Tianwen Xuebao* 30 (1989): 208–16, English abstract on 216.

190. Yabuuchi Kiyoshi, "Sōdai no seishuku" (Description of the constellations in the Song dynasty), *Tōhō Gakuhō* (Kyoto) 7 (1936): 42–90, and Pan Nai and Wang De-chang, "The Huang-You Star of the Song Dynasty—A Chinese Star List of the Early Medieval Period," *Chinese Astronomy and Astrophysics* 5 (1981): 441–48.

191. Pan, *Zhongguo hengxing guance shi*, 169–75 (note 7).

maps. Nothing of this nature appears to have survived, however.

In 1971 a fairly well preserved star map from the Liao dynasty (916–1125) was brought to light during excavations at Xuanhua in Hebei Province, not far from Beijing.[192] This map is painted on the ceiling of the tomb of Zhang Shiqing, a palace official and devout Buddhist who died in 1116 (fig. 13.22). The map has no pretensions to astronomical accuracy. Its main interest lies in the juxtaposition of a complete set of both the lunar lodges and the signs of the Western zodiac. Apart from fragmentary Tang illustrations (see above), it is the earliest extant example of such joint representation.

The circular Liao map is about 2.2 meters in diameter. At its center is a bronze disk, surrounded by replicas of red lotus petals. Immediately beyond is an illustration of the asterism Beidou, also in red, and several disks that presumably signify the sun, moon, and planets. Enclosing these figures are the twenty-eight *xiu* constellation patterns, shown in red and arranged in a circle. Finally, in an outer ring are depicted the twelve signs of the Western zodiac in a variety of colors. The symbol for Taurus has since become obliterated, but the remaining symbols are well preserved. The representations of Aries, Cancer, Leo, Libra, Scorpio, and Pisces are readily recognizable, but in keeping with the names found in Buddhist sutras, Gemini is portrayed by a man and woman, Virgo by two women, Sagittarius by a man with a horse, Capricorn by a sea-monster, and Aquarius by an ornate vessel.

Two other Sinified representations of the Western zodiacal signs survive from this period. Like the Liao star chart, both are closely associated with Buddhism. Among the decorative patterns on the sides of a large bell at Xingtai in Hebei Province are attractive and well-preserved illustrations of the twelve zodiacal signs.[193] This bell, more than 2 meters high and with a base circumference of 7.2 meters, was cast in 1174 during the Jin dynasty. Originally hung in Kaiyuan Buddhist Temple, it was recently moved to a nearby park. A series of rather well executed wall paintings of the zodiacal symbols were discovered early in the present century in the Caves of the Thousand Buddhas at Dunhuang (fig. 13.23).[194] These originate from sometime during the Xi Xia period (1032–1227).

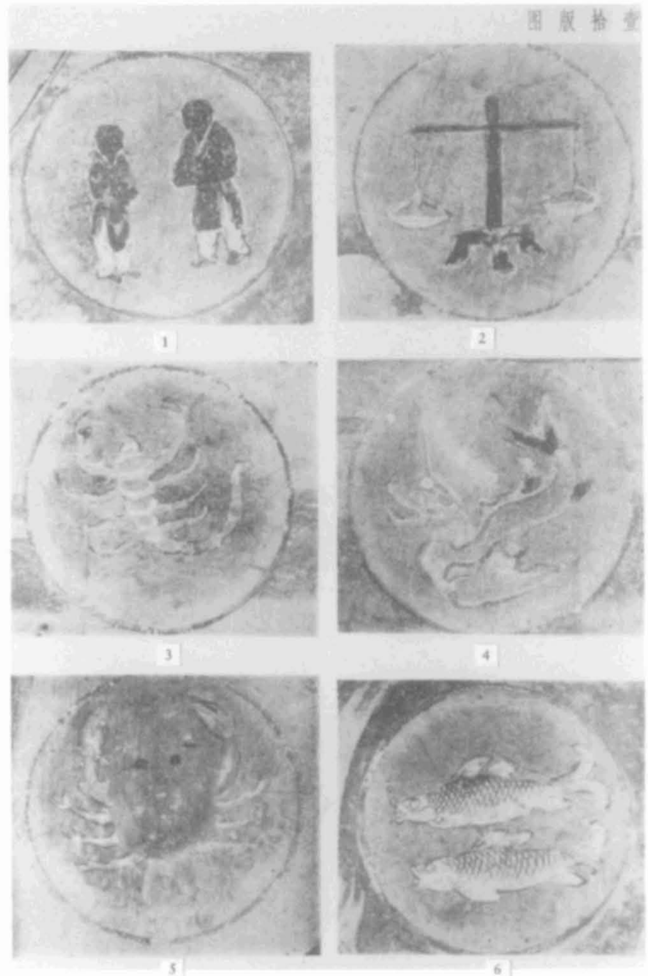


FIG. 13.23. XI XIA PERIOD ZODIACAL SYMBOLS. The Buddhist paintings shown here are part of a full series depicting the zodiacal symbols. In order are (1) Gemini, (2) Libra, (3) Scorpio, (4) Capricorn, (5) Cancer, (6) Pisces.
Size of each original: unknown. From Xia Nai, "Cong Xuanhua Liao mu di xingtu lun ershiba su he huangdao shier gong" (Discussion of the twenty-eight lunar lodges and twelve palaces of the ecliptic based on the star map from the Liao tomb at Xuanhua), reprinted in *Kaoguxue he keji shi* (Archaeology and the history of technology), by Xia Nai (Beijing: Kexue Chubanshe, 1979), 29–50.

THE YUAN AND MING DYNASTIES (1279–1644)

The Yuan dynasty was a time of considerable astronomical activity, as is evident from the extensive celestial observations recorded in the official history of the time by Song Lian et al., *Yuan shi* (History of the Yuan, compiled 1369–70). Along with the Song, the Yuan has been

192. Hebeisheng Wenwu Guanlichu, Hebeisheng Bowuguan (Hebei Province Cultural Relic Agency, Hebei Provincial Museum), "Liaodai caihui xingtu shi woguo tianwenshishang di zhongyao faxian" (The Liao period star map, an important discovery in the history of Chinese astronomy), *Wenwu*, 1975, no. 8:40–44; Edward H. Schafer, "An Ancient Chinese Star Map," *Journal of the British Astronomical Association* 87 (1977): 162; Yi Shitong, "Hebei Xuanhua Liao Jin mu tianwen tu jianxi-jianji xingtai tiezhong huangdao shier gong tu xiang" (A brief investigation of the star map from the Liao-Jin tombs at Xuanhua in Hebei—Also the twelve zodiacal signs as found on the Jintai iron bell), *Wenwu*, 1990, no. 10:20–24.

193. Yi, "Hebei Xuanhua Liao Jin mu tianwen tu jianxi-jianji xingtai tiezhong huangdao shier gong tu xiang" (note 192).

194. Xia, "Cong Xuanhua Liao mu di xingtu lun ershiba xiu he huangdao shier gong," esp. 47 and pls. 11–12 (note 167).

aptly described as the "heyday of Chinese astronomy."[195] It is therefore unfortunate that no astral globe or major star chart of the period is now extant. A celestial globe that was constructed at Beijing by the great astronomer and mathematician Guo Shoujing (1231–1316) survived until the eighteenth century, when it was melted down. The only extant star map that is probably of Yuan origin gives no hint of the level of attainment reached by Guo Shoujing and his contemporaries. This sectional chart is devoid of coordinates, and many of the constellation patterns have idealized forms. An outline of the history of the Yuan globe is given below, followed by a brief discussion of the sectional star map.

Between 1276 and 1279, Guo Shoujing equipped the imperial observatory at Dadu (Beijing) with a variety of new instruments, including a large celestial globe (*hun-tian xiang*). According to chapter 48 of the *Yuan shi*, this globe was six *chi* (some 1.7 m) in diameter, with graduations in both RA and declination. Both the celestial equator and the ecliptic were delineated, the later being "elevated above and depressed below the equator by 24 degrees [*du*] and a small fraction in each case." It was further stated that the globe was "placed upon a square box, the south and north poles being below and above the surface by 40 degrees and a large fraction, half of the globe being visible and half concealed. Within the box there are hidden toothed wheels set in motion by machinery for turning the globe."[196] Unfortunately, the representation of the constellations is not described. The value used for the obliquity of the ecliptic (a little more than twenty-four *du*) agrees well with the true result of 23.5 degrees. The figure of forty *du* "and a large fraction" for the altitude of the north and south poles also corresponds closely to the latitude of Beijing (39.9°).

The celestial globe and other instruments constructed by Guo Shoujing continued in use at Beijing throughout the remainder of the Yuan dynasty. About 1370 the first Ming emperor had them moved to his capital of Nanjing, where they continued to be used, despite the great difference in latitude between the two cities (almost seven degrees). Although the third Ming emperor restored Beijing as the capital in 1421, the Yuan instruments remained at Nanjing. Eventually, in 1437 the astronomer royal requested that wooden duplicates of the instruments at Nanjing be sent to Beijing.[197] Bronze replicas were then cast to equip the new Beijing observatory, which was established in 1442.

Little more is heard of either set of instruments for more than 150 years, but their subsequent history is far from happy. In 1599 (toward the end of the Ming dynasty), the celestial globe and other instruments manufactured by Guo Shoujing were inspected at Nanjing by the great Jesuit scholar Matteo Ricci (1552–1610), known to the Chinese as Li Madou. Although Ricci was unaware of either their exact date or their origin, he wrote that "it seems certain that they were molded when the Tartars were in power in China," but he was misguided in his rather biased assertion that their designer "had some knowledge of European astronomical science."[198] The following further extract from his journal provides some interesting details:

> They had installed here [at Nanjing] certain astronomical instruments or machines, made of cast metal which, in size and in elegance of design, surpassed anything of the kind as yet ever seen or read about in Europe. These instruments had stood the test of rain and snow and change of weather for nearly two hundred and fifty years [*sic*], with no detriment to their original splendor. There were four of the larger kind. . . .
>
> The first was a large globe. Three men with outstretched arms could scarcely encircle it. It was marked with meridians and parallels according to degrees, and it stood on an axis, set into a huge bronze cube in which there was a small door, for entrance, to turn the sphere. There was nothing engraved on the surface of this globe, neither stars nor zones. Hence it appeared to be an unfinished work. . . .
>
> Later on, Father Matthew (i.e., Ricci) saw similar instruments at Beijing, or rather duplicates of these, and undoubtedly cast by the same artisan.[199]

As Needham has emphasized, the effects of weathering on the celestial globe at Nanjing over more than three centuries may have been more severe than Ricci imagined.[200] The device survived a further century or so after Ricci viewed it. In 1670 it was taken to Beijing where, along with the other Yuan instruments, it was relocated at the imperial observatory. Three years later the Belgian Jesuit Ferdinand Verbiest, considering the Yuan artifacts useless, had them placed in storage to make way for new instruments that he had constructed. In 1688 both the Yuan and Ming instruments were viewed, gathering dust, by Louis Le Comte, another Jesuit missionary. Le Comte also noticed a further celestial globe about one meter in

195. Ho, *Li, Qi and Shu*, 164 (note 16).

196. Translated by Needham, Wang, and Price, *Heavenly Clockwork*, 137 (note 80).

197. For details, see Yu Jie and Yi Shitong, "Beijing gu guanxiangtai" (An ancient observatory in Beijing), in *Zhongguo gudai tianwen wenwu lunji* (Collected essays on ancient Chinese astronomical relics), ed. Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo (Archaeological Research Institute, Chinese Academy of Social Science [Academica Sinica] (Beijing: Wenwu Chubanshe, 1989), 409–14.

198. *China in the Sixteenth Century: The Journals of Matthew Ricci, 1583–1610*, trans. Louis J. Gallagher from the Latin version of Nicolas Trigault (New York: Random House, 1953), 331.

199. *China in the Sixteenth Century*, 329–31 (note 198).

200. Needham, *Science and Civilisation*, 3:368 (note 5).

diameter, which was of relatively coarse construction.[201] Nothing further is known regarding this device. In 1715 all the Yuan instruments and all but four of the Ming copies were melted down, with imperial sanction, by the Jesuit astronomer royal of China, Bernard Stumpf, who needed the bronze to manufacture new quadrants.[202] The four Ming replicas that escaped destruction included the celestial globe and three other devices: an armillary sphere, a simplified armillary, and a gnomon. Today the celestial globe seems to have disappeared, possibly as a result of the Boxer Rebellion in 1900, but the other three instruments can still be seen at Purple Mountain Observatory, Nanjing, having been transferred from Beijing in 1931.

Pan Nai has reproduced copies of a series of small sectional constellation maps (some seventy-five in all) that he attributes to Guo Shoujing. These depict up to about four asterisms. Star groups, and in many cases their constituent stars, are named, but the various diagrams contain no reference coordinates or even indications of the relative locations of the individual sections. The constellation patterns are in general highly idealized, and among them many symmetrical forms (especially circles) are evident. Pan found these maps along with other material that he attributes to Guo Shoujing in the National Library, Beijing, in a Ming compilation titled *Tianwen huichao* (A collection of manuscripts on astronomy).[203]

Guo Shoujing, who held the post of astronomer royal under Kubilay Khān, is regarded as the inventor of the equatorial mounting.[204] Among his various writings is the calendar treatise in chapters 52–57 of the *Yuan shi*. He is known to have produced two catalogs of stars soon after he constructed the equipment for the Beijing observatory. These were titled: *Xin ce ershiba shezazuo zhuxing ruxiu quji* (Newly measured positions of the twenty-eight lunar lodges and the various known asterisms) and *Xin ce wuming zhuxing* (Newly measured positions of those stars without names).[205] The latter catalog evidently contained details for previously uncharted stars. Although both catalogs were thought to have been lost long ago, Pan recently uncovered what appears to be a partial copy of the first in the same Ming collection of manuscripts in which the sectional star maps were found.[206] He made a careful examination of the text of this catalog and compared the details with the briefer information listed in the *Yuan shi* calendar treatise. As a result, he asserted that he had found a copy of Guo Shoujing's first catalog containing many original positional measurements. In this work the coordinates (RA and NPD) of 741 stars—all expressed to the nearest 0.1 *du*—are still preserved. Pan gives full details, including an annotated version of the catalog. By comparing the measured coordinates, corrected for precession, with those in a modern catalog, he was able to identify nearly all the stars in terms of their Western equivalents.

In the calendar treatise of the *Yuan shi*, Guo cites measurements of the widths of the *xiu* and the NPDs of the determinant stars he made in 1280. These values are also quoted to the nearest 0.1 *du*. Comparison with the corresponding values computed by Pan[207] reveals a mean error in the widths of the lunar lodges of about four arc minutes. They are thus of considerably higher precision than the corresponding Song determinations. Although the mean error in the Yuan measurements of NPD is relatively large (nineteen arc minutes), it is apparent from inspection of the results that the discrepancies result partly from a faulty latitude setting of the instrument.

The Yuan measurements reveal that by 1280 the width of the narrowest lunar lodge (Zuixi) had decreased to almost zero owing to relative precession between its determinative star (φ′ Ori) and that of the adjacent *xiu* Shen (δ Ori) (see table 13.1). Guo's result for the equatorial extent of Zuixi (0.05 *du*), corresponds to only about three arc minutes, but actually the width had already become negative by approximately this amount, so that Zuixi had effectively vanished! The lunar lodge was tacitly assumed to exist with negligible width until its redefinition early in the Qing dynasty by the Jesuit astronomer Johann Adam Schall von Bell (see below).

Early in the Yuan dynasty (1267), the Persian astronomer Jamāl al-Dīn, of Maragheh observatory, brought a number of astronomical instruments to Beijing as a gift from Hūlāgū Khān (or his successor) to Kubilay.[208] These devices, which included a celestial globe and an astrolabe, are described in chapter 48 of the *Yuan shi*.[209] Because they were designed for ecliptic measurements (rather than equatorial) and were graduated into 360 degrees, they attracted little attention among Chinese astronomers such as Guo Shoujing. Throughout much of the Yuan dynasty, there were Arab astronomers at the court of Beijing. Afterward, when the Ming dynasty was established (1368), an Islamic astronomical bureau, known as

201. Louis Henry Le Comte, *Nouveaux mémoires sur l'état présent de la Chine*, 2 vols. (Paris: Anisson, 1696), 1:138–48.

202. Aloys Pfister, *Notices biographiques et bibliographiques sur les Jésuites de l'ancienne mission de Chine, 1552–1773*, 2 vols. (Shanghai: Mission Press, 1932–34), 2:645.

203. Pan, *Zhongguo hengxing guance shi*, fig. 40 and p. 276 (note 7).

204. Needham, *Science and Civilisation*, 3:377–82 (note 5).

205. Pan, *Zhongguo hengxing guance shi*, 276 (note 7).

206. For details, see Pan, *Zhongguo hengxing guance shi*, 276 ff. (note 7).

207. Pan, *Zhongguo hengxing guance shi*, 272–73 (note 7).

208. For details, see Needham, *Science and Civilisation*, 3:372–75 (note 5).

209. The astrolabe was unfamiliar to the Chinese, who could not even decide on a name for it. There is no evidence that astrolabes were ever used by Chinese astronomers.

the Huihui Sitianjian, was set up in parallel with the traditional bureau. The Arab astronomers were particularly concerned with calendar problems and mathematical astronomy; their impact on Chinese uranography appears to have been insignificant. Even when the Jesuits arrived at Beijing in the early seventeenth century, the Islamic bureau was still active.

After the high point astronomy reached during the Song and Yuan dynasties, the Ming was a period of decline. There were no significant advances in positional measurement, and there is no evidence that any major astral charts or star catalogs were produced.[210] In his valuable article on the astronomical bureau in Ming China, Ho cites several examples of official incompetence, including inadequate understanding of the setting of astronomical instruments, calendar discrepancies, and serious errors in predicting eclipses.[211] In keeping with this unhappy situation, surviving Ming astral charts prove to be of very mediocre quality, although one can argue that they are not necessarily representative of the best of Ming astral cartography. No Ming celestial globes are now known to exist.

Charts of the night sky in the Chinese style produced either by or in association with Jesuits during the late Ming (and also Qing [1644–1911]) dynasties will be discussed below. The rest of this section is confined to indigenous Ming artifacts. Extant Ming star maps are of two basic types: circular charts displaying the whole of the night sky as visible from northern or central China, and sets of sectional star maps.

Three circular astral charts that survive from the Ming, each depicting the night sky as seen from China, take the following forms: (1) a painting formerly on the ceiling of a Buddhist temple at Longfu, near Beijing (dated 1453); (2) a stone engraving at Changshu in Jiangsu Province (dated 1506); and (3) a paper diagram preserved at a former Daoist temple in Putian, Fujian Province (date sometime after 1572).[212] Before discussing details peculiar to each individual map, I shall summarize the principal features common to all three charts.

All the planispheres bear a general resemblance to the great Suzhou chart of the Song dynasty. Each is on a polar (equidistant) projection. Both the circle of constant visibility and the celestial equator are displayed, while the edge of each chart forms the circle of constant invisibility. The boundaries of the lunar lodges are represented by radial lines extending from the circle of constant visibility to the periphery of the map. Stars are depicted by circles that are joined into groups by straight lines. On any one map, symbols denoting the stars are of roughly equal size. As is typical of most pre-Jesuit charts, no attempt is made to distinguish between stars of different brightness. At the periphery of both the Longfu and Changshu charts, details such as the names of the *xiu*, *ci* (Jupiter stations), and directions are marked as on the Suzhou map. This information is absent in the Putian artifact.

The oldest surviving Ming star map is from the Longfu Temple near Beijing (fig. 13.24). This painting, on cloth mounted on an octagonal wooden board (diameter about 1.8 m), was discovered in 1977 when the temple, which had been built in 1453, was being demolished. In 1901 the temple had been extensively damaged by a fire, but fortunately the central hall remained intact. The chart of the night sky, which is 1.6 meters in diameter, displays 1,420 stars in gold on a blue background.[213] It has since been moved to the Beijing Ancient Observatory. Very few constellation names are marked, and neither the ecliptic nor the Milky Way is shown. If the equator is accurately positioned, the circle of constant visibility is at a declination of +60°, while the boundary of the map is at −62°. These declinations are more appropriate for southern China than for the neighborhood of Beijing. Measurements I have made on the scale drawing published by the Archaeological Research Institute, Academia Sinica[214] indicate that although the extent of each of the lunar lodges is fairly accurately depicted (to the nearest degree or so), stars are in general crudely positioned, and the form of several asterisms is highly idealized. Standard errors in the declinations of twenty selected bright stars are as large as seven or eight degrees, making identification difficult in several instances.

A somewhat more recent artifact is the Changshu planisphere, engraved on stone in 1506 (fig. 13.25). This stele is now preserved in the Office of Cultural Relics at Changshu, Jiangsu Province, not far from Suzhou. Like the Suzhou star map, it is titled *Tianwen tu* (Astronomical chart), and it appears to be modeled on the Song artifact. The Changshu stele measures 2.0 by 1.0 meters and is 24 centimeters thick; the astral chart itself is 70 centimeters in diameter.[215] All together, 1,466 stars are depicted in 284 constellations, essentially the traditional figures of antiquity. Both the Milky Way and the ecliptic are shown. The circle of constant visibility is at a declination of +52°, while the map extends to −53°; both values are

210. Other sciences also lost ground during the Ming. For example, in mathematics there was hardly any work of value between the beginning of the dynasty and 1500. See Ho, *Li, Qi and Shu*, 106 (note 16).

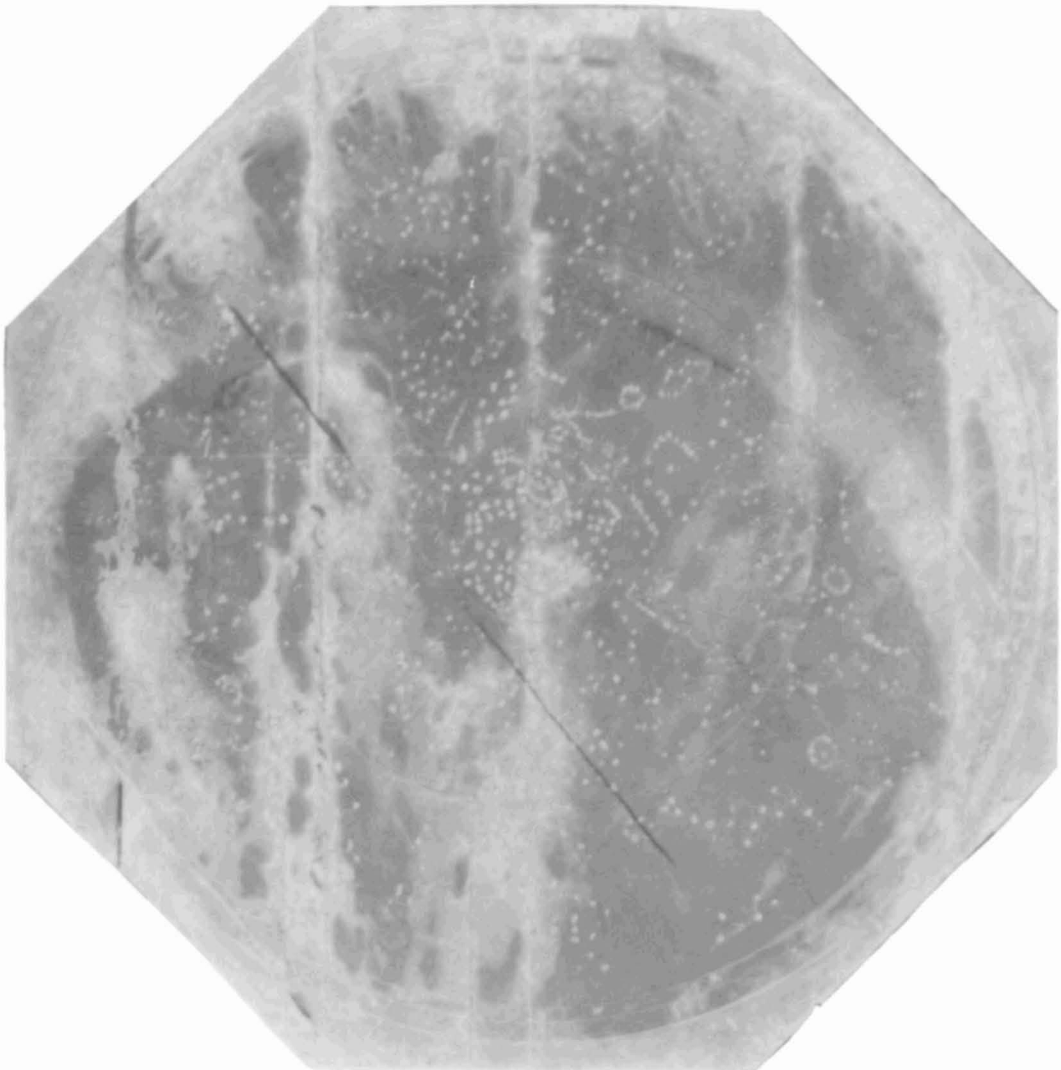
211. Ho Peng-yoke, "The Astronomical Bureau in Ming China," *Journal of Asian History* 3 (1969): 137–57.

212. Photographs or drawings of all three are in *Zhongguo gudai tianwen wenwu tuji*, 96–99 (note 6); the first and third are in Pan, *Zhongguo hengxing guance shi*, figs. 64 and 70 (note 7).

213. *Zhongguo gudai tianwen wenwu tuji*, 125 (note 6); Pan, *Zhongguo hengxing guance shi*, 309–10 (note 7). When I inspected the map in 1992 it was in poor condition, but restoration was planned.

214. *Zhongguo gudai tianwen wenwu tuji*, 96 (note 6).

215. For details, see *Zhongguo gudai tianwen wenwu tuji*, 125 (note 6), and Pan, *Zhongguo hengxing guance shi*, 316–18 (note 7).



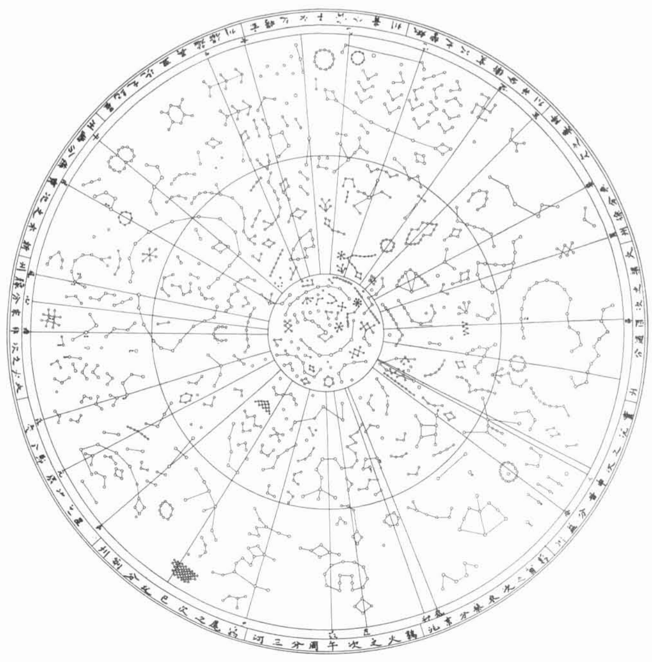


FIG. 13.24. PHOTOGRAPH AND DRAWING OF THE STAR MAP FROM LONGFU TEMPLE, 1453. The painting is on cloth and displays 1,420 stars in gold on a blue background. There are many similarities with the Suzhou star chart (fig. 13.21), although the precision is much less.
Diameter of the original: 160 cm. Photograph courtesy of Ancient Observatory, Beijing. Redrawing from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 96.

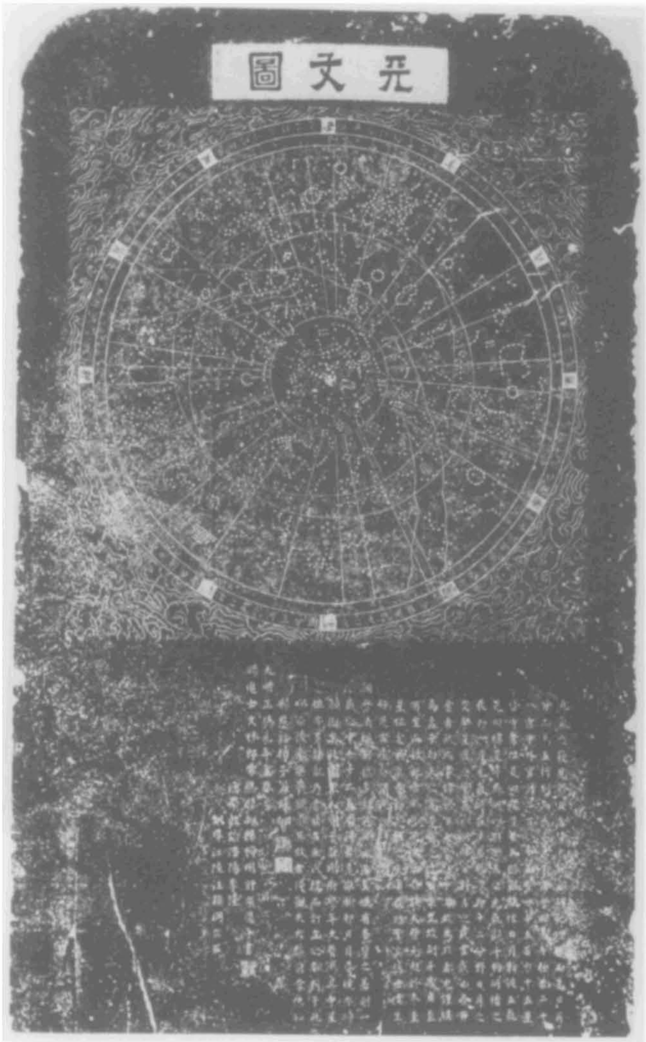


FIG. 13.25. RUBBING OF THE CHANGSHU STONE PLANISPHERE OF 1506. This chart closely resembles the Suzhou stele, but the constellations are depicted with relatively low accuracy. The equator and ecliptic are depicted in such a way that they intersect at exactly 180 degrees apart; an unusual feature at this epoch.
Diameter of the original: 70 cm. Office of Cultural Relics, Changshu, Jiangsu Province. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 97.

more suitable for northern China than Jiangsu. Although the equinoctial points are 180 degrees apart (a result that seems to be deliberately obtained by allowing the radii of the equator and ecliptic to vary slightly), the obliquity is only 19 degrees. Constellations are individually named. As with the Longfu planisphere, the widths of individual *xiu* are fairly accurately represented, but the stars are only approximately positioned, and some of the constellation patterns show idealized form. Although the Changshu map bears only general similarity to the Longfu painting, errors in the positioning of individual stars are of comparable magnitude.

The third Ming planisphere, printed on paper sometime after 1572, is now in poor condition. Fortunately, Pan has produced a careful scale diagram (fig. 13.26).[216] The full size of the sheet of paper is 150 by 90 centimeters; the astral chart is 60 centimeters in diameter. In all, 1,400 stars—grouped into 288 asterisms—are displayed on the chart. The Milky Way is not represented. An indication of the date when the chart was produced is given by the positioning of the 1572 guest star (a brilliant supernova that appeared in Cassiopeia) but not that of the one in 1604 (the next bright supernova, occurring in Ophiuchus).[217] Although the circle of constant visibility and the rim of the chart are concentric with the focal point of the boundaries of the lunar lodges (the north celestial pole), both the celestial equator and the ecliptic are badly misplaced. The latter two circles intersect 180 degrees apart, but their centers are both 10 degrees from—and on opposite sides of—the center of the chart. Tracing the paths of the equator and ecliptic in relation to the nearby constellations reveals fair accord with the true relative positions. The implication is that the constellations are misplaced and distorted to accommodate the highly erroneous equatorial and ecliptic circles. This curious artifice seems to be unique in Chinese history, but a late eighteenth-century Korean celestial map exhibits close parallels (probably independently; see below).

An extensive series of astral diagrams, most of them devoted to small sections of the night sky, is printed in the *Sancai tuhui* (Illustrated compendium of the three powers [heaven, earth, man], compiled by Wang Qi and printed in 1609) (fig. 13.27). The various diagrams were evidently produced with minimal measurement. The principal map in this collection depicts the night sky down to about declination −55° on a polar (equidistant) projection. This is accompanied by a large number of sectional maps: for example, the region between the zones of constant visibility and constant invisibility (between about +60° and −55° declination) is shown in twenty-eight rectangular strips each centered on a separate *xiu*. Additional charts are devoted to the north circumpolar region. The outline of the Milky Way is delineated on those sections that cover the appropriate part of the sky. Once again, there is no attempt to discriminate between stars of different brightness; stars are represented by cir-

216. Pan, *Zhongguo hengxing guance shi*, fig. 70 (note 7).

217. *Zhongguo gudai tianwen wenwu tuji*, 99 and 125 (note 6). A detailed discussion of the supernovas of 1572 and 1604 is given by Clark and Stephenson, *Historical Supernovae*, chaps. 10 and 11 (note 2).

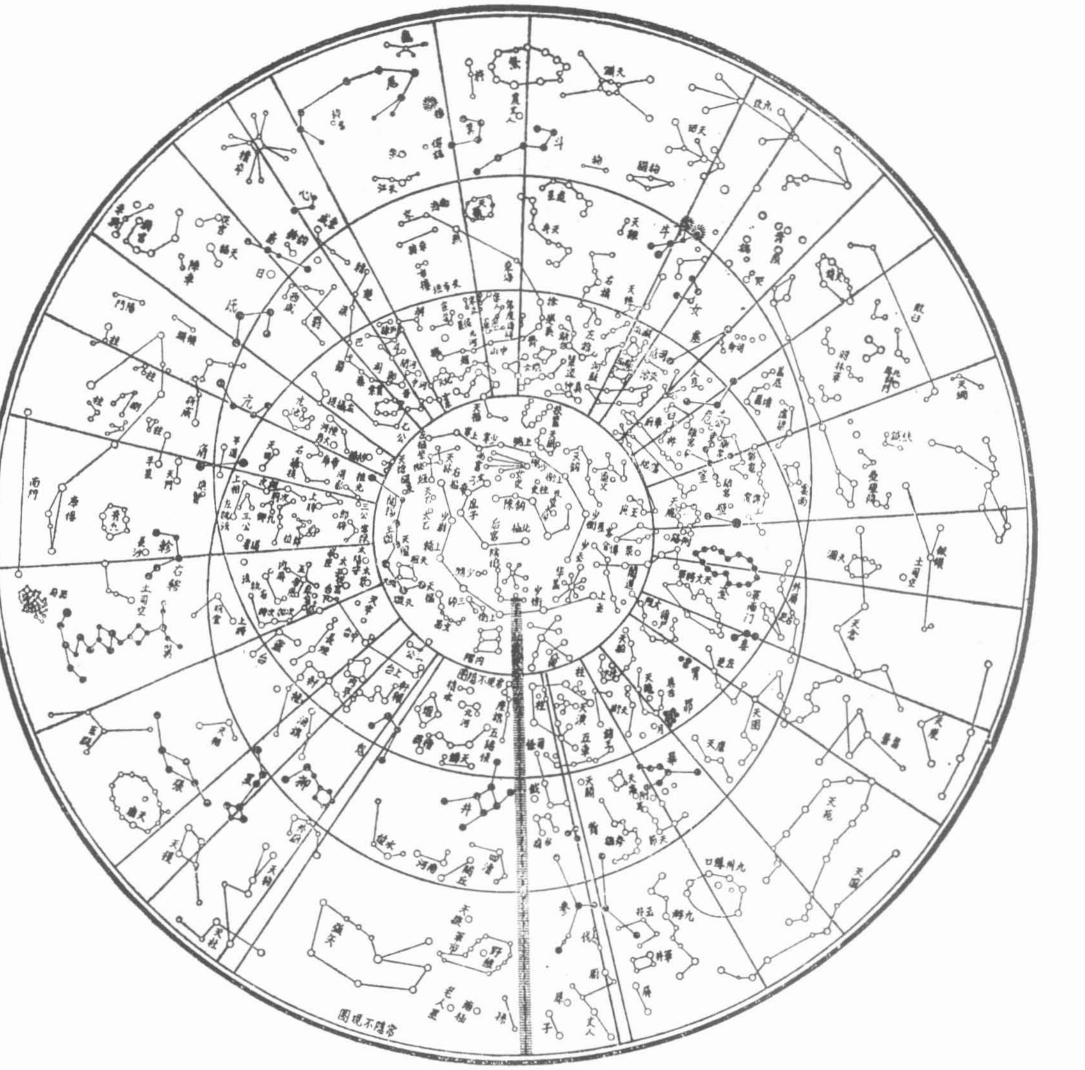


FIG. 13.26. SKETCH OF A MING PAPER PLANISPHERE. Although the precise date of this planisphere is not known, it can be deduced as sometime between 1572 and 1604, since the position of the supernova in the former year is marked but not that of the one in 1604. The original is at the Tianhougong Temple, Putian. Note that both the equator and the ecliptic are offset, an unusual device.
Diameter of the original: 60 cm. From Pan Nai, *Zhongguo hengxing guance shi* (Shanghai, 1989), fig. 70.

cles of equal size, joined into constellations by straight lines. Each constellation is individually named.

Charts showing sketches of a few selected constellations are preserved in Mao Yuanyi's *Wubei zhi* (Treatise on military preparations, compiled ca. 1621).[218] This work contains four such maps designed to assist navigation in the Indian Ocean. The diagrams, although roughly executed, are of particular interest since they depict several far southern asterisms, including Denglonggu (the Frame of the Lantern [the Southern Cross]) (fig. 13.28).[219]

Celestial Cartography in Korea

Because of its proximity to China, the history of Korea has been strongly influenced by its more powerful neighbor since ancient times, and this is true of Korean astronomy and astrology as well. The earliest relics of astronomical significance that have been uncovered in

218. These charts are discussed by George Phillips, "The Seaports of India and Ceylon, Described by Chinese Voyagers of the Fifteenth Century, Together with an Account of Chinese Navigation," *Journal of the Royal Asiatic Society, North China Branch* 20 (1885): 209–26, esp. 216–18. See also Joseph Needham, *Science and Civilisation in China* (Cambridge: Cambridge University Press, 1954–), vol. 4, pt. 3, with Wang Ling and Lu Gwei-djen, *Physics and Physical Technology: Civil Engineering and Nautics* (1971), 564–67.

219. These diagrams are reproduced and discussed in *Zhongguo gudai tianwen wenwu tuji*, 94–95 and 124–25 (note 6).

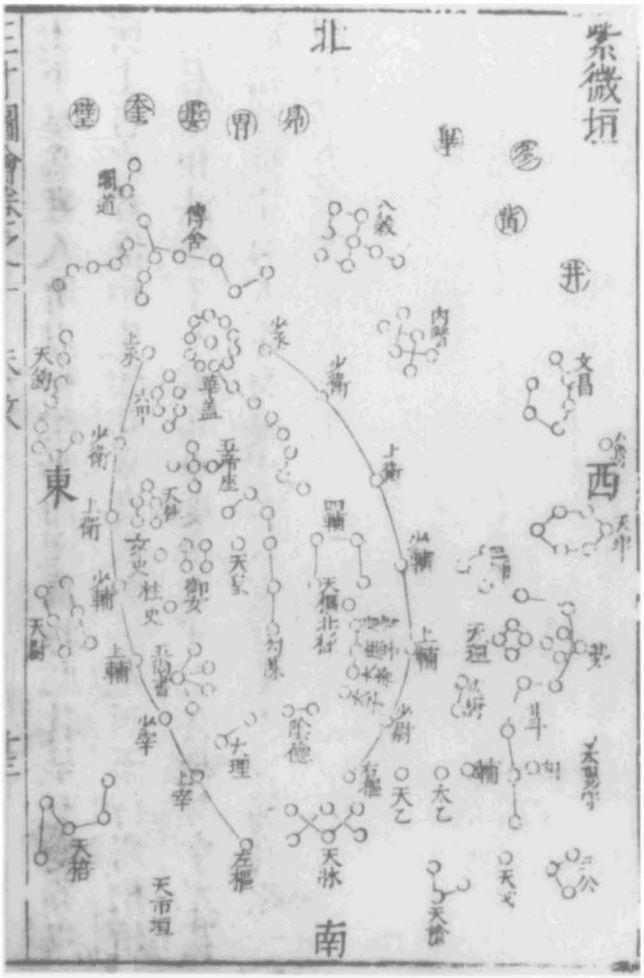


FIG. 13.27. PRINT OF A SECTION OF A STAR MAP IN THE *SANCAI TUHUI* SHOWING CONSTELLATIONS IN THE PURPLE PALACE (CONSTANT VISIBILITY) REGION. This is one of a series of crude star charts, first printed in 1609. Size of the original: 21 × 14 cm. From Wang Qi, comp., *Sancai tuhui* (1609 edition), *tianwen* 1.13a. Photograph courtesy of the Harvard-Yenching Library, Harvard University, Cambridge.

Korea are of Chinese origin. These are two cosmic boards depicting the Big Dipper and the twenty-eight lunar lodges (for details on the construction and use of cosmic boards, see above). Both instruments date from the first century B.C. and were discovered in the tombs of Chinese officials near modern P'yŏngyang.[220] At the time, the Han dynasty had established several commanderies in the northern part of present-day Korea.

No specifically Korean astronomical artifacts or reliable written records of celestial phenomena appear to have survived from before about 500. By this time, the three independent kingdoms of Koguryŏ, Paekche, and Silla had long since been established in the Korean peninsula. From this Samguk (Three Kingdoms) period, star maps have so far been found only in Koguryŏ. Several charts, consisting of representations of a few selected constellations in the Chinese style, have been uncovered in tombs dating from about 500. A scale diagram of one of these maps on the ceiling of a tomb near the Yalu River—along the present-day border between China and Korea—has been published by Jeon.[221] The chart illustrates seven of the twenty-eight lunar lodges with fair precision, Wei (the Tail of the Dragon) being particularly prominent. Similar examples occur in other Koguryŏ sepulchers, and these also clearly reveal Chinese influence.

Paintings of the four creatures, which in Chinese mythology represent the quarters of the sky, are found on the interior walls of several tombs near P'yŏngyang (the site of the Koguryŏ capital). The beautifully colored illustrations in one of these mausoleums dating from about 550 have been judged among the best paintings in the Orient that survive from this period.[222] On the east wall of the main chamber is depicted the Azure Dragon, on the south wall the Red Bird (fig. 13.29), on the west wall the White Tiger and on the north wall opposite the entrance the Dark Warrior (represented as in China by a turtle entwined with a snake) (fig. 13.30).

It is by way of Koguryŏ that the oldest example of detailed celestial cartography from anywhere in East Asia has come down to us, even though only late copies of the original star map are extant. The earliest of these reproductions, now in a Seoul museum, was engraved on stone in 1395. This chart is inscribed with brief details of its history that are essentially confirmed by Korean historical works.[223] It is related that at some unknown date a star map incised on stone was presented to the king of Koguryŏ by a Chinese emperor, an event that is unfortunately not recorded in Chinese history. This artifact was carefully preserved at P'yŏngyang until 670, when it suffered an ignominious fate; it was submerged in the nearby Taedong River when Koguryŏ was conquered by the Silla army. Although the stele was never recovered, many centuries later (1392) a rubbing from it was presented to the founder of the Yi dynasty. The king was so impressed with his gift that not long afterward he

220. For further information, see W. Carl Rufus, "Astronomy in Korea," *Transactions of the Korea Branch of the Royal Asiatic Society* 26 (1936): 4–48, esp. 4–6.

221. See Jeon, *Science and Technology in Korea*, fig. 1.1 (note 5).

222. Good-quality reproductions of these paintings have been published; see, for example, Editorial Staff of Picture Albums, ed., *Korean Central Historical Museum* (P'yŏngyang: Korean Central Historical Museum, 1979), 56–59.

223. The history of this star chart is outlined in Hongmun Kwan (Royal Library), *Chŭngbo Munhŏn pigo* (Documentary reference encyclopedia, expanded and supplemented) (Seoul: Empire of Korea, 1908)—see W. Carl Rufus, "The Celestial Planisphere of King Yi Tai-jo," *Transactions of the Korea Branch of the Royal Asiatic Society* 4, pt. 3 (1913): 23–72, esp. 37–38.

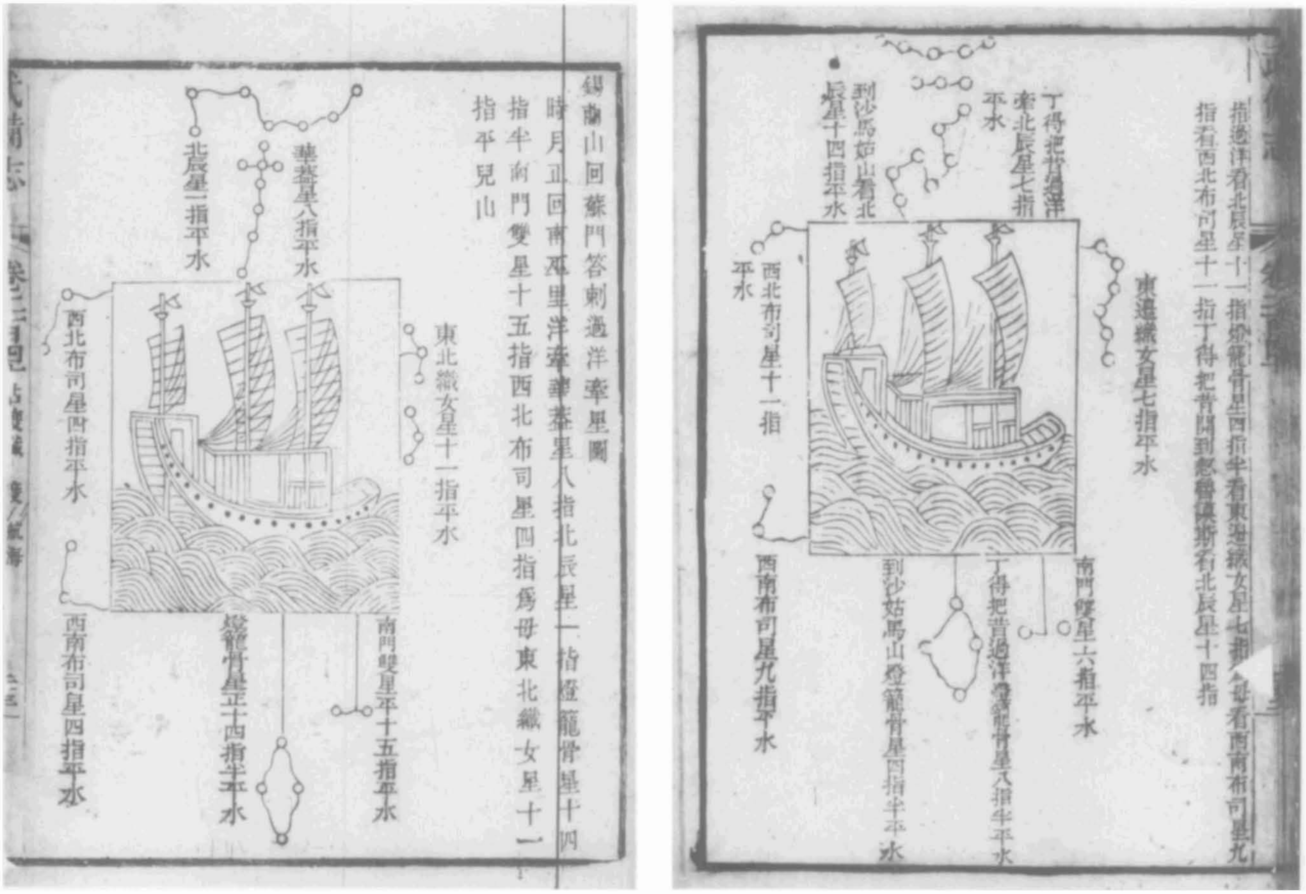


FIG. 13.28. MING NAVIGATIONAL CHARTS IN THE *WUBEI ZHI*. These charts were produced as aids to navigation in the Indian Ocean. The two far southern constellations are Nanmen (Southern Gate [α and β Centauri]) at the right and Denglonggu (The Frame of the Lantern [Southern Cross]) to the left of Nanmen.
Size of the original: unknown. Courtesy of the Geography and Map Division, Library of Congress, Washington D.C.

had a new engraving made on a block of marble. Since this stele dates from long after the Samguk period, I will consider it in detail later in this section.

What may well have been an observatory is still standing at Kyŏngju, the site of the Silla capital (fig. 13.31). This bottle-shaped structure, known as Ch'ŏmsŏngdae (Star Observing Tower), was built in 647, the sixteenth year of Queen Sŏndŏk.[224] It is some nine meters tall, and varies in diameter from about five meters at the base to three meters at the top. Although there has been dispute whether the tower was actually used as an observatory or was merely symbolic of Silla's astronomy, it implies a developed astronomy at this period.[225]

After its conquest of Koguryŏ and Paekche about 670, Silla ruled the peninsula for another 250 years, a period roughly contemporaneous with the Tang dynasty in China. The *Samguk sagi* (History of the Three Kingdoms, compiled by Kim Pusik, 1145) relates that in 692 a Buddhist monk named Tojŭng brought a star chart from China.[226] Unfortunately, nothing is known about its construction, and there appears to be no parallel account in Chinese history. Also from the *Samguk sagi*, we learn that in 749 Silla appointed a "director in charge of astrology."[227]

More than fifty separate observations of celestial phenomena, notably eclipses, comets, meteors, and lunar and planetary movements, are recorded in the *Samguk sagi* during the period of Silla ascendancy.[228] From these records it is apparent that the Silla sky watchers followed much the same style of observation as their Chinese counterparts and in particular adopted the Chinese constel-

224. For a detailed description of Ch'ŏmsŏngdae, see Kim Yong-woon, "Structure of Ch'ŏmsŏngdae in the Light of the Choupei Suanchin," *Korea Journal* 14, no. 9 (1974): 4–11.

225. Jeon, *Science and Technology in Korea*, 33–35 (note 5), favors the identification of this structure as an observatory; Kim, "Structure of Ch'ŏmsŏngdae" (note 224), is more cautious.

226. Kim Pusik, comp., *Samguk sagi*, chap. 8; see the edition in 9 vols. (Kyŏngju, 1512; reprinted Seoul, 1931).

227. *Samguk sagi*, chap. 9 (note 226).

228. These observations are scattered throughout chaps. 6–12 of the *Samguk sagi* (note 226).

FIG. 13.29. KOGURYŎ TOMB ILLUSTRATION OF RED BIRD. Appropriately, this is painted on the south wall of a tomb. This and the other illustrations on the walls are particularly exquisite (see also fig. 13.30).
Size of the original: unknown. From Editorial Staff of Picture Albums, ed., *Korean Central Historical Museum* (P'yŏngyang: Korean Central Historical Museum, 1979), 57.

lation patterns. Thus in the *Samguk sagi* the positions of about twenty comets and meteors seen after 670 are specified in relation to Chinese star groups, including several of the lunar lodges. Observations such as these suggest that the Silla astronomers possessed star maps, presumably of Chinese origin, of at least tolerable utility. Since the *Samguk sagi* does not give any actual measurements of position (in terms of degrees), however, we have no way of knowing how accurate such charts might have been.

During the whole of the Koryŏ dynasty, founded by Wang Kŏn in 918 and lasting until 1392, virtually no direct information is available either on the acquisition of Chinese star maps and catalogs by Koreans or on the production of such artifacts by native astronomers. A brief note in the *Koryŏ sa* (History of Koryŏ, 1451), the official history of the period, mentions that a star chart was made by O Yun bu, who died in 1305. This short biographical sketch asserts that O Yun bu was an assiduous observer who watched all night long despite heat or cold. His chart is said to have "harmonized all the doctrines," but unfortunately no further description of it survives.[229]

Despite the lack of information on star maps from Korea during the Koryŏ dynasty, there is ample evidence that this was a period of great astronomical activity. The astronomical records in the *Koryŏ sa* (chaps. 47–49) include numerous reports of comets, lunar and planetary movements, and meteors. These records reveal that, as in China, the principal motive for celestial observation was astrological. Although the Chinese division of the night sky into constellations was systematically adopted by the Korean astronomers, however, they interpreted the celestial phenomena they witnessed as omens affecting their own ruler and country.[230] Some of the cometary records in the *Koryŏ sa* are particularly detailed, and these show that the sky watchers of the Korean court possessed an extensive knowledge of the constellations. For instance, the motion of a comet through the circumpolar region in 1110 is described relative to as many as nine separate asterisms.[231] No positional measurements are preserved in the *Koryŏ sa*, but one can scarcely doubt that good-quality star maps were available to the official astronomers at the capital of Songdo (Kaesŏng).

Accounts of the movements of comets, and of the moon, planets, and meteors in the *Koryŏ sa*, mention virtually all the star groups mapped by the Chinese astronomers, including the lunar lodges. Many of these asterisms are referred to time after time in separate Korean records. It is apparent that in Korea there was a negligible independent tradition of mapping the constellations. The numerous accurately dated references in the *Koryŏ sa* to the passage of the moon or five bright planets through or near asterisms are of special interest. By computing the celestial coordinates of the moon and planets on the stated dates (reduced to the Julian calendar), it is possible to approximately delineate the outlines of the star groups in the zodiacal region.[232] On this basis there do not appear to be any marked discrepancies between the constellation patterns as recognized by the Korean and Chinese astronomers at this period, though there seems to be ample

229. Chŏng Inji et al., comps and eds., *Koryŏ sa*, chap. 122; see the edition in 3 vols. (Seoul: Asea Munhwasa, 1972). The *Koryŏ sa* follows the format of a traditional Chinese dynastic history, with annals, monographs, and biographies.

230. See, for example, Park, "Portents and Neo-Confucian Politics" (note 13).

231. *Koryŏ sa*, chap. 47 (note 229).

232. Pan and Wang, "Huang-You Star," 441 (note 190). I have made similar investigations, as yet unpublished.

FIG. 13.30. KOGURYŎ TOMB ILLUSTRATION OF BLACK TURTLE. Painted on the northern wall of the same tomb as figure 13.29, this illustration shows a turtle entwined with a snake—a fairly common representation of the Dark Warrior of the North.

Size of the original: unknown. From Editorial Staff of Picture Albums, ed., *Korean Central Historical Museum* (P'yŏngyang: Korean Central Historical Museum, 1979), 58.

opportunity for further research in this aspect of the history of celestial cartography.

About 1200, the astronomical treatise of the *Koryŏ sa* begins to cite occasional records in which stars are numbered within their respective constellations; for example, an observation in 1223 in which the planet Venus "invaded the fifth star of Nandou."[233] Numbering of individual stars within asterisms had begun in China by at least the first century B.C. (see above), but until about 1200 there is little evidence of this practice in Korea. By this latter date Korean astrography had apparently progressed so far that such refinement was considered desirable. It is unfortunate, however, that instances of star numbering in the *Koryŏ sa* are so sporadic that systematic comparison with the contemporary Chinese numbering scheme—by calculating lunar and planetary movements—seems scarcely viable.

In 1389 the Koryŏ government was overthrown by Yi Sŏnggye, and as King T'aejo (r. 1392–98) he established a new dynasty named Yi. This was to last for more than five hundred years—until the Japanese annexation in 1910. In 1394 King T'aejo moved his capital to Hanyang (Seoul), where it was to remain throughout the dynasty. Finding the official astronomers of the fallen dynasty incompetent, he organized a new astronomical board, the *sŏun'gwan*. At the same time, new books pertaining to astronomy and astrology were compiled.[234] The observations made by the *sŏun'gwan*—in both this and later periods—are summarized in the *Chosŏn wangjo sillok* (Royal annals [*sillok*] of Chosŏn), a series of extensive chronicles of events occurring during the reigns of the first twenty-five kings of the Chosŏn dynasty.[235] These observations follow much the same style as those

233. *Koryŏ sa*, chap. 49 (note 229).

234. Rufus, "Astronomy in Korea," 22 (note 220).

235. These cover the period from 1392 to 1863. (Korea was known as Chosŏn during these years [also called the Yi dynasty].) The *Koryŏ sa* was probably largely compiled from similar material that has long since disappeared.

FIG. 13.31. SILLA OBSERVATORY (CH'ŎMSŎNGDAE), KYŎNGJU, BUILT IN 647. Opinions have differed over the exact nature of this structure. If it is an observatory (as its name suggests), it is the oldest surviving building of this nature anywhere in the world.
Photograph courtesy of F. Richard Stephenson.

reported in the *Koryŏ sa*, although they are often more detailed.

A major astrographical achievement during the reign of King T'aejo was the engraving in 1395 of a star map based on a preserved rubbing of an ancient stele. This stele had been lost when Koguryŏ fell in 670. Brief details regarding the history of this chart have already been given above. Rufus translated part of the inscription found on extant copies of the 1395 chart as follows:

> Many years having passed since it was lost, existing rubbings of the original were also [believed to be] out of stock.
>
> However, when His Majesty [King T'aejo] began to reign, a man having one of the originals tendered it to him. His Majesty prized it very highly and ordered the court astronomers to engrave it anew on a stone model. The astronomers replied that the chart was very old and the degrees of the stars were already antiquated; so it was necessary to revise it by determining the present midpoints of the four seasons and the culminations at dark and dawn and to engrave an entire new chart designed for the future.
>
> His Majesty responded, "Let it be so!"[236]

Preparations for the new celestial planisphere were begun not long after King T'aejo ascended the throne. This work was carried out by a team of astronomers under the supervision of Kwŏn Kŭn and other senior members of the board of astronomy.[237] A preliminary manuscript version was prepared in the summer of 1395. Rufus was able to inspect this chart, and he noted that the central star map was inverted compared with the final version.[238] Unfortunately, this manuscript can no longer be traced. By December 1395, the circular astral chart was engraved on a huge block of black marble bearing the caption *Ch'ŏnsang yŏlch'a punyajido* (Chart of the constellations and the regions they govern). The accompanying inscription, as well as providing a historical summary, contains a variety of astronomical tables and other information.[239]

The principal motive of King T'aejo in having a reproduction made of the old star map may well have been "to acquire new star charts as symbols of the royal authority of the new dynasty."[240] The result is the survival of what may well be a copy of a very early Chinese star map. In the *Chŭngbo Munhŏn pigo* (an eighteenth-century historical compendium), it is asserted that although the inscription on the Koguryŏ chart had been updated, "the astrography according to the old chart (itself) . . . was engraved directly on stone."[241]

Today it is not possible to assess the evidence that convinced the astronomers of King T'aejo that the rubbing presented to their ruler was indeed taken from the ancient Koguryŏ star map rather than some other early astral chart. However, although the surface of the stele, which was engraved in 1395, is now damaged, several high-quality reproductions are preserved, and these reveal that the astrography they are based on is very archaic.

The 1395 stele, which weighs about a ton, has approximate dimensions of 2.1 meters high by 1.2 meters wide by 12 centimeters thick; the circular star map itself is about 90 centimeters in diameter.[242] Damage has occurred on several occasions owing to fire, water ero-

236. Rufus, "Celestial Planisphere," 31–32 (note 223).
237. Jeon, *Science and Technology in Korea*, 26 (note 5).
238. Rufus, "Astronomy in Korea," 23 (note 220).
239. A full translation of the inscription is provided by Rufus, "Celestial Planisphere," 29 ff. (note 223).
240. Jeon, *Science and Technology in Korea*, 25 (note 5).
241. *Chŭngbo Munhŏn pigo*, chap. 2 (note 223).
242. See Na Ilsŏng, "Chosŏn sidae in chŏn'mun ŭigi yŏn'gu" (Study

sion, and transport—for example, during the Japanese invasion in 1592 when the building it was housed in was destroyed.[243] The chart is now on exhibit at the Royal Museum in Toksugung Palace in Seoul.

On a visit to Seoul in October 1993 I was able to inspect and photograph the stele. Except for a small section (covering about 10 percent of the planisphere) that is badly worn, all asterisms can be clearly discerned, as well as the Milky Way, coordinate circles, and boundaries of the lunar lodges. It is on record that 120 rubbings of the stone were made in 1571,[244] suggesting that the whole surface was then in sound condition. Presumably all of these rubbings have long since disappeared.

Fortunately, an accurate seventeenth-century replica of the planisphere of King T'aejo is still in a good state of preservation. This reproduction was engraved on a block of white marble in 1687 at the command of King Sukchong (r. 1674–1720) (figs. 13.32 and 13.33).[245] Its plane dimensions are almost the same as those of the original stele, although the thickness (30 cm) is considerably greater.[246] The newer engraving is stated to be a faithful copy of the older stele, except that the title has been moved to the top.[247] It is currently exhibited at the King Sejong Memorial Museum in Seoul, where a framed rubbing is also on view. The following description is based on an examination of photographs of rubbings made available to me.[248]

The central astral chart is circular, approximately ninety centimeters in diameter, and is on a polar (equidistant) projection centered on the north celestial pole. On this chart, stars are denoted by dots, nearly all of similar size. Canopus, Sirius, and one or two other bright stars are represented by unusually large dots, but as on Chinese astral maps of the pre-Jesuit era there is no systematic attempt to indicate brightness. Stars are joined into groups by straight lines. Two concentric circles represent the northern circumpolar boundary and the celestial equator. Assuming that the equator is accurately positioned, the declination of the north circumpolar circle is +52°. The chart is bounded by the circle of constant invisibility, whose declination is −55°. Both of these declinations would be adequate for use in central and northern China as well as Korea. As is usual in East Asian star charts produced before the Jesuit period, the ecliptic is incorrectly shown as a circle. The boundaries of the twenty-eight lunar lodges are represented by radial lines extending from the north circumpolar circle to the rim of the chart.

Although the Milky Way is portrayed with fair precision, the outlines of the various asterisms are crudely depicted. Each asterism is individually named, but the configurations of stars sometimes differ widely from the forms represented on medieval Chinese maps. A count by Rufus and Chao indicated 1,464 stars—agreeing with the canonical number according to the "ancient schools,"[249] but the number of asterisms (totaling 306) is quite different from the Zhanguo tradition (283).

The circular edge of the chart is graduated in *du*, or solar degrees. Immediately surrounding this is a narrow band divided into twelve equal arcs. Each of these sections is labeled in three separate ways: (1) with the Chinese equivalent of one of the signs of the Western zodiac; (2) with one of the twelve "terrestrial branches," as direction indicators; and (3) with the name of the archaic Chinese state that from ancient times was believed to be governed by the stars in this sector. The implied links between 1 and 3 are curious; there is, of course, no direct correspondence between the signs of the zodiac—which are based on the ecliptic—and any Oriental divisions of the sky, including the twelve Jupiter stations.[250] Additionally, since the chart is equatorial (the customary practice for pre-Jesuit artifacts), the regular spacing of the zodiacal signs represents only a very crude approximation to reality.

Most of the names of the signs of the zodiac have close parallels with the names found in Chinese translations from the Sanskrit of Buddhist sutras made from the sixth century onward (see above). In order we have: White Sheep (Aries), Golden Bull (Taurus), Male and Female (i.e., yin-yang: Gemini), Great Crab (Cancer), Lion (Leo), Two Women (Virgo), Celestial Balance (Libra), Celestial Scorpion (Scorpio), Man and Horse (Sagittarius), Sea Monster (Capricorn), Precious Water Bottle (Aquarius), and Two Fish (Pisces).[251] It seems likely that these

of astronomical instruments in the Chosŏn period), *Tongbang hakchi* 42 (1984): 205–37, esp. 209.

243. *Chŭngbo Munhŏn pigo*, chap. 3 (note 223).

244. *Sŏnjo sillok* (Annals of King Sŏnjo, r. 1567–1608), chap. 5; see Kuksa P'yŏnch'an Wiwŏnhoe (National History Compilation Committee of the Republic of Korea), ed., *Chosŏn wangjo sillok* (Royal annals of Chosŏn), 48 vols. (Seoul: Kuksa P'yŏnch'an Wiwŏnhoe, 1955–58).

245. Historical details are given by Rufus, "Celestial Planisphere," 27 (note 223).

246. See Na, "Chosŏn sidae," 212 (note 242).

247. Jeon, *Science and Technology in Korea*, 28 (note 5).

248. K. L. Pratt of the University of Durham, who on a visit to the King Sejong Memorial Museum photographed both the stele and the framed rubbing, kindly supplied me with copies of his photographs. I am also grateful to Na Ilsŏng of Yonsei University, Seoul, for a further photograph of a rubbing in his possession.

249. See, for example, Rufus, "Astronomy in Korea," fig. 24 (note 220); W. Carl Rufus, "Korea's Cherished Astronomical Chart," *Popular Astronomy* 23 (1915): 193–98, esp. pl. X; W. Carl Rufus and Celia Chao, "A Korean Star Map," *Isis* 35 (1944): 316–26, esp. 316–17 (showing a negative print of a rubbing); and Jeon, *Science and Technology in Korea*, fig 1.3 (note 5).

250. Rufus and Chao, "Korean Star Map," 326 (note 249).

251. The various translations of the Korean names of the twelve zodiacal signs are by Rufus, "Astronomy in Korea," table 3 (note 220).

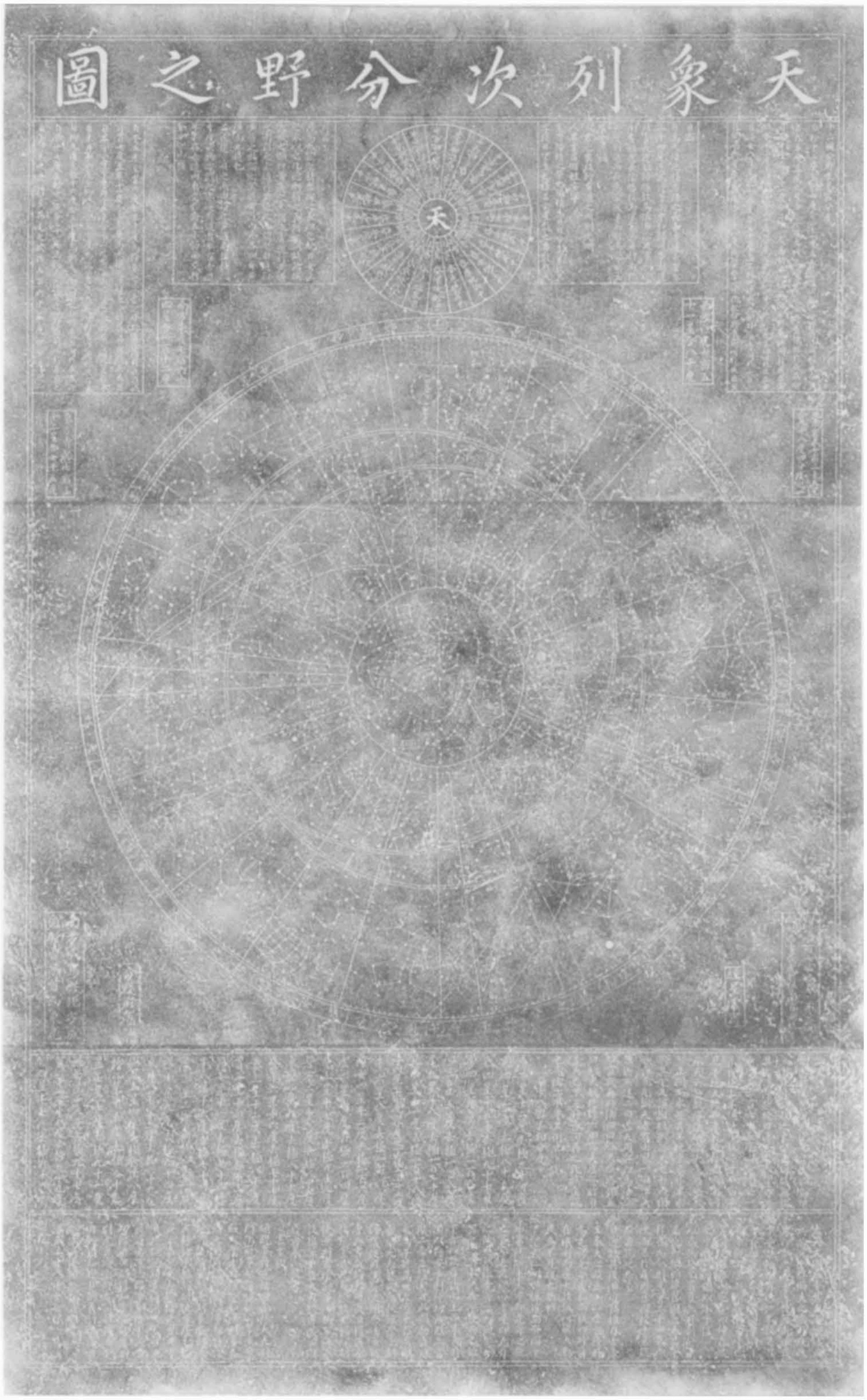


FIG. 13.32. RUBBING OF A 1687 COPY OF THE 1395 STAR MAP. The stele from which this rubbing was made is reputed to be an accurate copy of a star map engraved on stone in 1395. The 1395 map was based on a rubbing of a Chinese stone chart lost in 670. Calculations yield a date of about 30 B.C.. Diameter of the original: ca. 90 cm. By permission of the King Sejong Memorial Museum, Seoul.

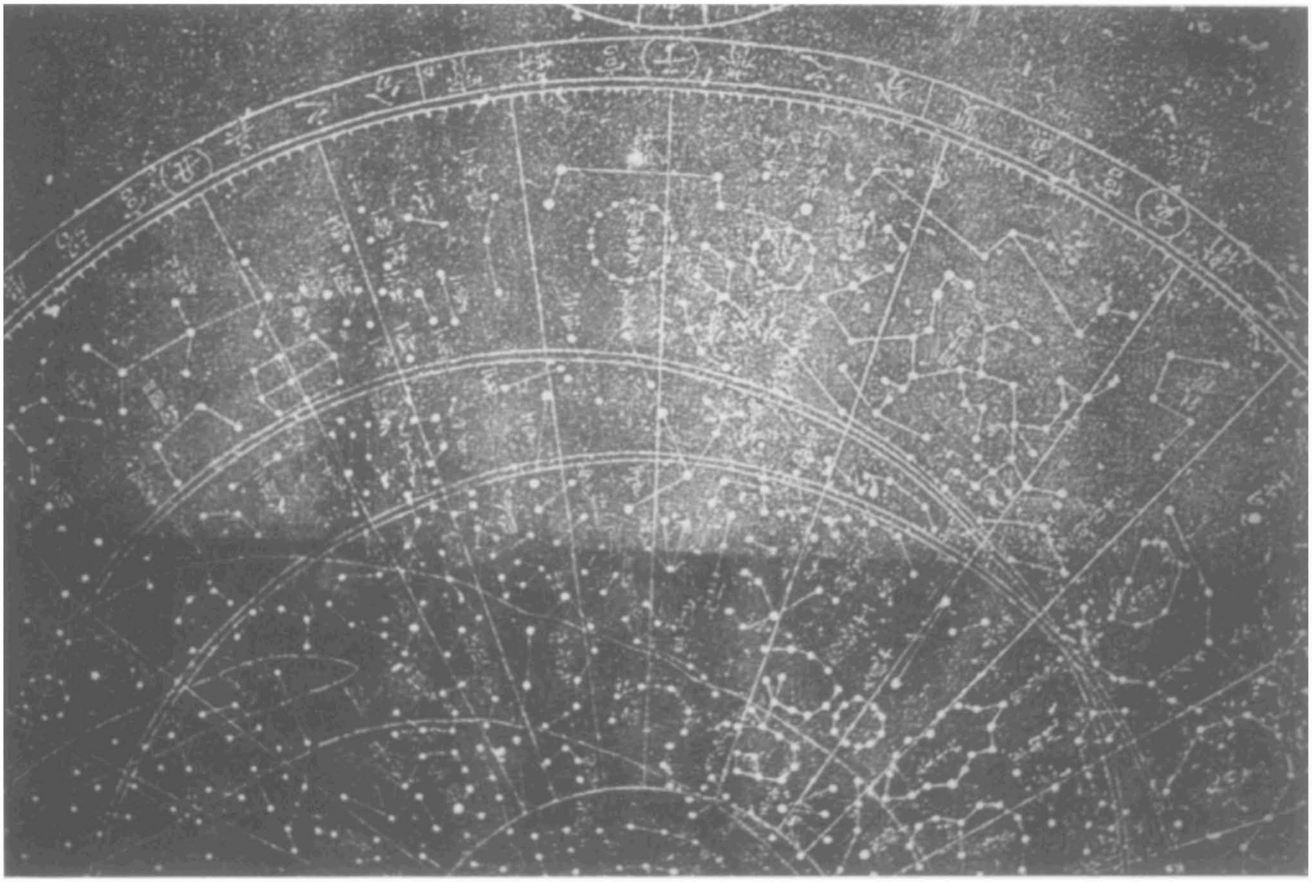


FIG. 13.33. DETAIL OF FIGURE 13.32. Section of chart shown in figure 13.32 with details of the ecliptic, equator, Milky Way, circle of constant visibility, and lunar lodge boundaries, as well as numerous constellations.

King Sejong Memorial Museum, Seoul. Photograph courtesy of K. L. Pratt, Durham University.

names were already inscribed on the 1395 stele. Incorporation of the signs of the zodiac in an officially produced star map is rather surprising. In China we find no parallel on any star map produced by official astronomers, and in any event the Yi rulers did not embrace Buddhist doctrines but were overtly Confucian in their philosophy.

The inscription accompanying the Korean star chart gives several indirect indications of the date of production of the lost original. It is stated that the equinoxes were "in the east, a little preceding the fifth degree of Jue (the first lunar lodge) and in the west a little beyond the fourteenth degree of Kui (the fifteenth *xiu*)." These positions indicate a date between 40 and 20 B.C.[252] Measuring of the location of the autumnal equinox on the star map itself yields a similar date. (The vernal equinox is shown several degrees in error, but this discrepancy arises merely because the ecliptic is depicted as a circle.) In general, the positions of the stars are inaccurately marked. On the assumption of a date about 30 B.C., analysis of the NPDs of twenty selected bright stars measured on the chart indicates a standard error of plus-or-minus five degrees.[253] Although of low precision, these NPDs are definitely more compatible with an ancient than a medieval origin.

An early date for the original chart is also indicated by the table of lunar lodges inscribed immediately below the star map in existing copies. This table lists the number of stars in each *xiu*, followed by the equatorial extent and the NPD of the determinative star. Coordinates are expressed to the nearest *du*. The widths of the various *xiu* represented on the chart itself agree fairly accurately (to within about a degree) with those in the accompanying table. The NPDs of the determinative stars are less carefully plotted, however, with typical errors amounting to several degrees. Rufus implied that King T'aejo's astronomers had included new determinations of these coordinates,[254] but this statement proves incorrect. All of

252. These are my computations, as yet unpublished.

253. These computations are also mine.

254. Rufus, "Astronomy in Korea," 24 (note 220).

FIG. 13.34. PLANISPHERE FOUND IN A JAPANESE JUNK AND NOW IN EDINBURGH. A navigational device that is an accurate copy of a Japanese bronze planisphere produced in 1668 that was in turn a careful copy of the 1395 Korean planisphere.
Diameter of the original: 34.5 cm. ©The Trustees of the National Museums of Scotland 1993 (NMS T1878.37).

the tabular *xiu* widths are in exact accord with those cited in the ancient *Xingjing* (see above). In the case of the NPDs for determinative stars, there is also good general agreement with the *Xingjing*, although the significant number of differences suggests some independence here. Comparison of the recorded NPDs in the table with computed values indicates a date within about a century of the birth of Christ,[255] a result that adequately supports the date deduced from the equinox locations. Although the inscription on the 1395 stele (as found in extant copies) alleges that it "was designed for the future," there seems to be little direct evidence to support this assertion.

A further seventeenth-century reproduction—in bronze—of the 1395 planisphere is preserved in Japan (see the discussion and illustration below, chapter 14). This artifact, known as a *Bundo no kiku*, was produced by the Japanese astronomer Fukushima Kunitaka in 1668. An exact copy of this replica, also in bronze, is now in the Royal Scottish Museum, Edinburgh. Its date of construction is unknown, but it was apparently recovered from a Japanese junk wrecked on an island off the coast of Japan sometime during the previous century (fig.

255. Computations, as yet unpublished, are mine.

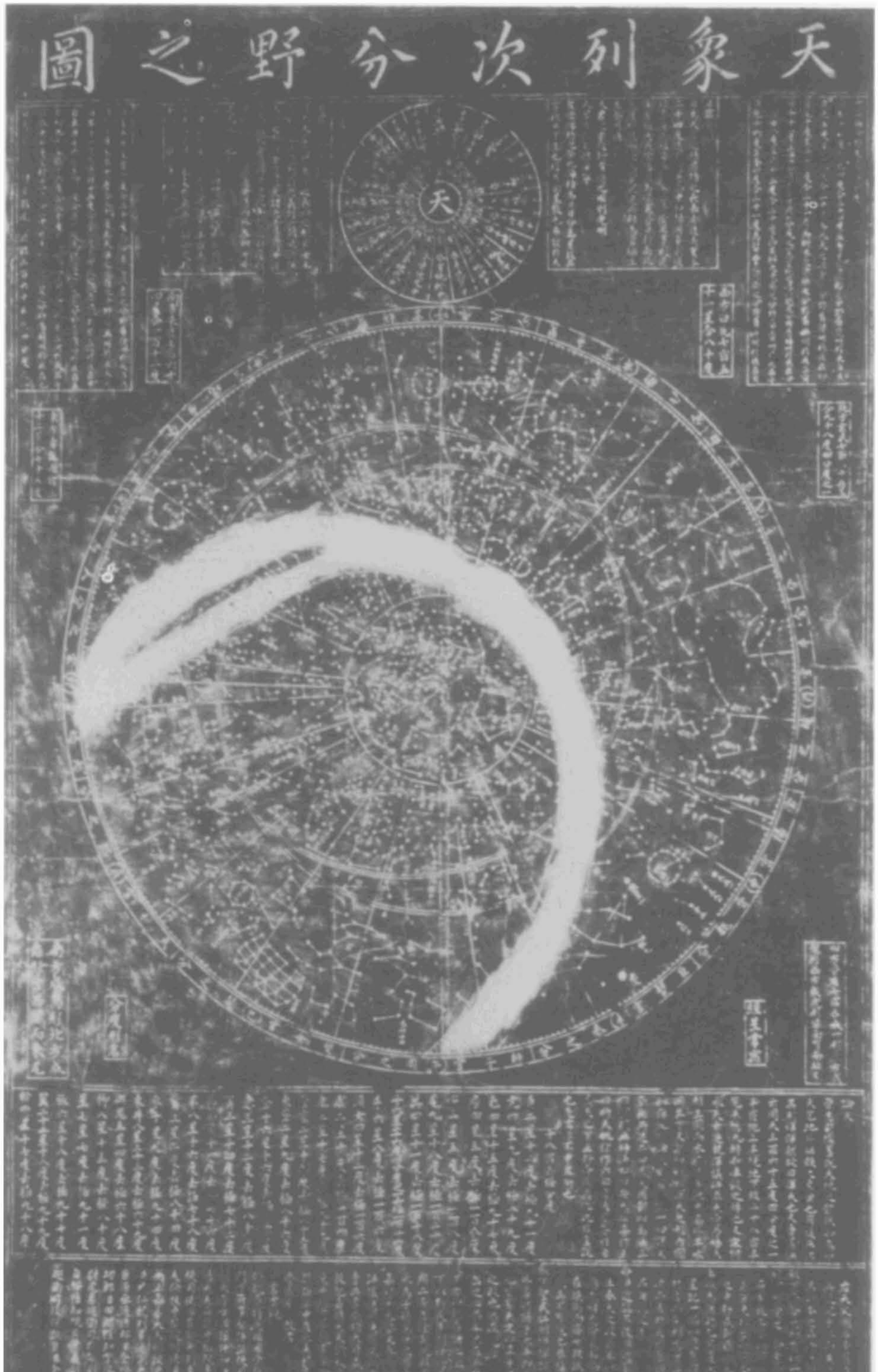


FIG. 13.35. BLOCK PRINT COPY OF THE 1395 STAR MAP. Most prints of this star map show the Milky Way very prominently, as here. The accord with the 1687 stele shown in figure 13.32 is excellent. The text contains a history and description of the chart, as on the stele itself. Size of the copy: unknown. Photograph courtesy of Na Ilsŏng, Yonsei University Observatory, Seoul.

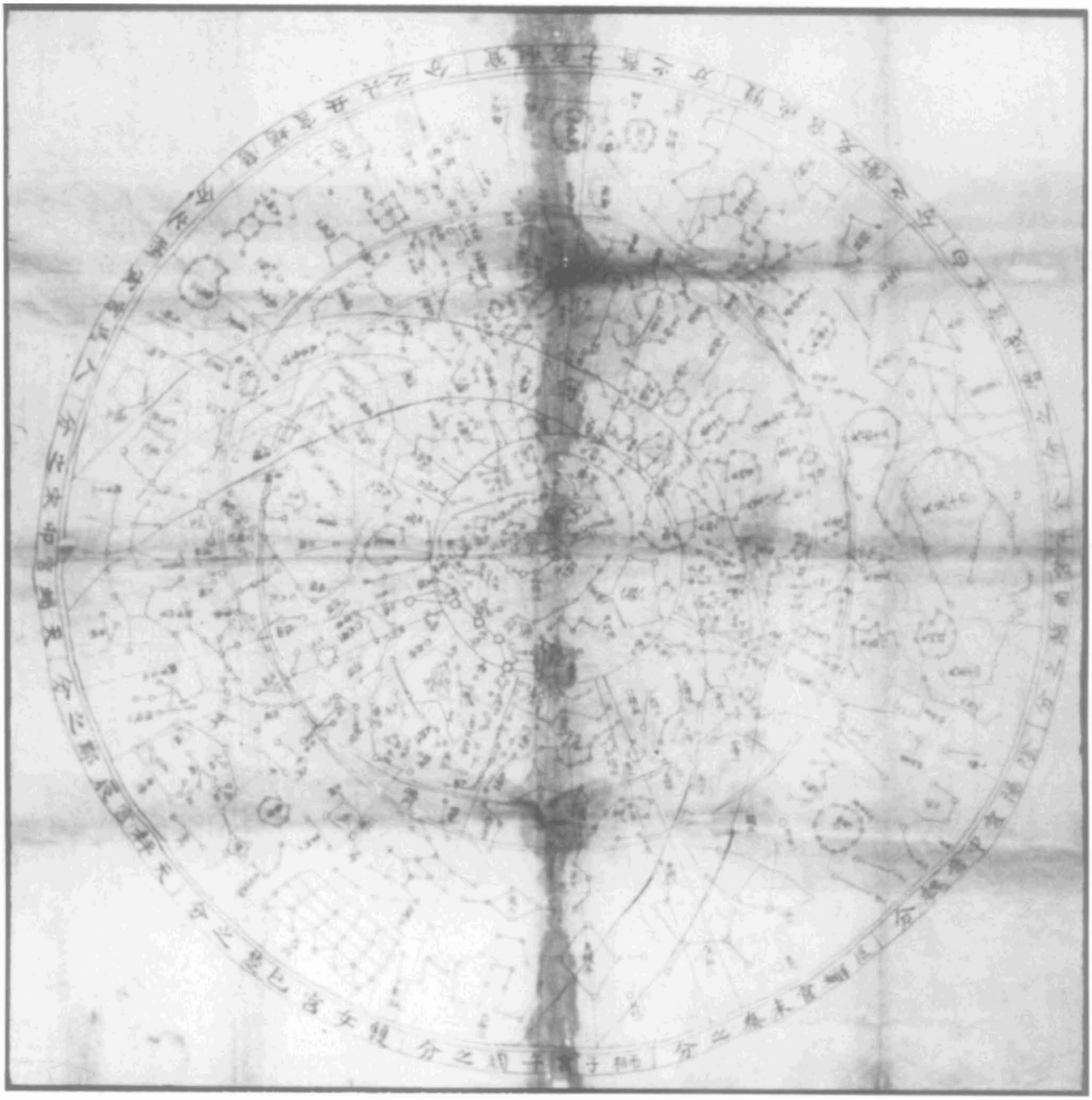


FIG. 13.36. MANUSCRIPT COPY OF THE 1395 STAR MAP. Although the date of this copy is unknown, it is probably late (perhaps nineteenth century). Size of the copy: unknown. Photograph courtesy of Na Ilsŏng, Yonsei University Observatory, Seoul.

13.34).[256] This navigational instrument has two small compasses inset near its edges. Rufus and Chao seem to have been the first to recognize the identity of its astrography with that on the Korean star map.[257] The device is in a fine state of preservation.[258]

The *Bundo no kiku* in the Edinburgh collection has an overall diameter of about thirty-four centimeters; the star chart itself is twenty-four centimeters across. Stars are represented by raised dots, joined into groups.

256. E. B. Knobel, "On a Chinese Planisphere," *Monthly Notices of the Royal Astronomical Society* 69 (1909): 435–45.

257. Rufus and Chao, "Korean Star Map," 317 (note 249).

258. Knobel, "Chinese Planisphere," pls. 17 and 18 (note 256), and F. Richard Stephenson, "Mappe celesti nell'antico Oriente," *L'Astronomia*, no. 98 (1990): 18–27, esp. 22. See also Clark and Stephenson, *Historical Supernovae*, pl. 5 (note 2).

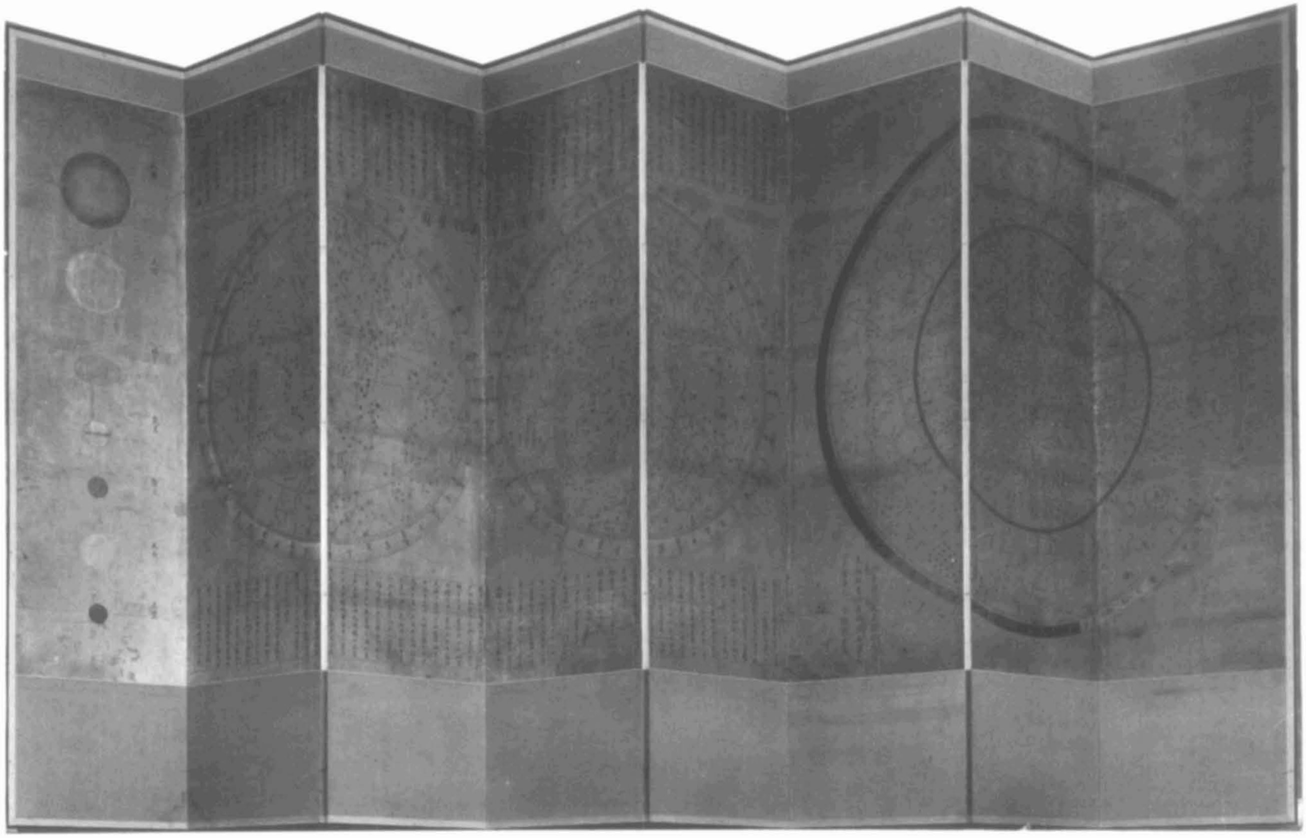


FIG. 13.37. KOREAN FOLDING SCREEN. This colorful screen depicts both the 1395 planisphere (on the right) and a double hemisphere chart produced in China by the Jesuit astronomer Ignatius Kögler in 1723. Size of the original: 230 × 440 cm. By permission of the Whipple Museum of Science, Cambridge.

Although constellation names are absent, the uranography (including circles and *xiu* boundaries) is otherwise an accurate copy of that on the 1395 Korean map.

Several early copies of the 1687 planisphere are still preserved, in a variety of forms. These include: block prints (fig. 13.35); manuscript copies (fig. 13.36); and silk screens. At least six block prints, probably dating from the eighteenth century, are known to be preserved in museum and library collections. These are about the same size as the stele itself and depict the stars as white dots on a black background. The Milky Way is boldly represented—as a white band—but otherwise the prints closely resemble rubbings from the stone. Many hand copies of the stele, some no more than a century old, are preserved.[259]

One example of a silk screen is in the Whipple Museum of Science in Cambridge, England, to which it was presented by a Korean collector. This reproduction, dating from 1755-60 (fig. 13.37), is painted on an ornate eight-panel folding screen, approximately 4.4 by 2.3 meters, that also depicts two star charts of Jesuit origin (see below). It was discussed in detail first by Needham and Lu and more recently by Needham et al.[260] Stars are represented either by red or black dots or by open circles on a buff background and are joined by straight lines into named constellations. Although the astrography differs considerably from that on the Dunhuang charts, there are certain striking similarities. In particular, the distribution of stars marked in each color (red, black, and yellow) on the two maps agrees well, once again recalling the ancient groupings. However, much further historical research would be necessary in order to adequately explain these equivalences.

On the Korean screen, the ecliptic is depicted in yellow, as befits the "Yellow Road," and correspondingly the celestial equator is marked in red. The edges of the lunar lodges are also clearly marked. Close examination shows that this star map is a faithful reproduction of the chart of 1687—it is by no means purely decorative.

259. Information in this paragraph concerning copies 1 and 2 is from Na Ilsŏng (personal communication).

260. Needham and Lu, "Korean Astronomical Screen" (note 137), and Needham et al., *Heavenly Records*, 153-79 (note 5).

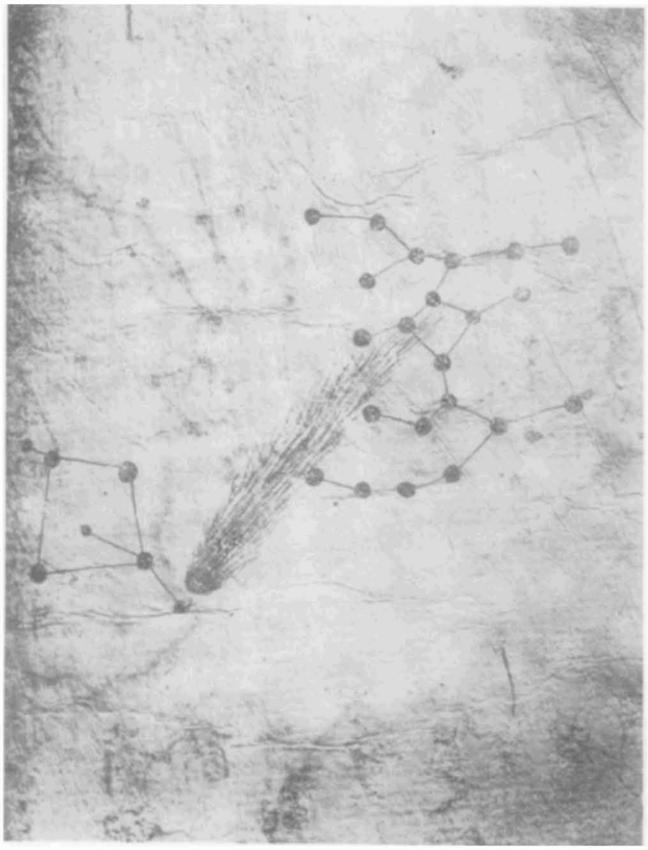


FIG. 13.38. KOREAN SKETCH OF POSITION OF COMET OF 1664. This sketch by the court astronomers is probably typical of many that were produced in Korea and probably China. Alas, virtually all of these have disappeared, including the original of the drawing shown here.
From W. Carl Rufus, "Astronomy in Korea," *Transactions of the Korea Branch of the Royal Asiatic Society* 26 (1936): 4–48, esp. fig. 27.

The existence of such a variety of copies shows that the celestial planisphere of King T'aejo was highly prized for several centuries, but little is known about how the chart was regarded by the official astronomers of the later Yi dynasty or about its influence on Korean celestial cartography. Possibly the stele was valued mainly as a historical relic; it is difficult to imagine that such an archaic representation of the night sky could have fulfilled a serious role in positional astronomy. Apart from errors in the positions of the stars, the visibility of the constellations would have been significantly affected by precession. For example, some constellations marked on the chart would no longer be visible in the latitude of Korea, while others that were not depicted would have come into view. Unfortunately, only minimal information is preserved regarding indigenous uranography during the Yi dynasty. Apart from occasional sketches of individual constellations by the court astronomers—for example, to indicate the position of comets (fig. 13.38)—no other pre-Jesuit star maps or celestial globes are known to be preserved.

The *Chŭngbo Munhŏn pigo* relates that a planisphere was carved in stone in 1433, but no details are provided. Soon afterward, in 1437, King Sejong had a celestial globe installed at his newly constructed royal observatory. At his death in 1450 this observatory is said to have "possessed one of the finest and most complete sets of astronomical instruments in the world."[261] The following description of the celestial globe is found in the official chronicle of the time, the *Sejong sillok* (Annals of King Sejong, r. 1418–50):

> The celestial globe was made of lacquered cloth (on a framework), round as a crossbow-bullet, having a circumference of 10.86 feet [equivalent diameter about 75 cm]. Coordinates were marked on it in celestial degrees [*du*]; the equator was in the middle with the ecliptic crossing it at an angle of a little under 24 degrees. All over the cloth surface were marked the constellations north and south of the equator.[262]

Unfortunately, the record is silent on whether the astrography on the globe was based on new measurements or it was at least partially dependent on the 1395 chart. The celestial globe apparently remained in use for fully a century; after possibly undergoing repairs in 1526, it was replaced by a replica in 1549. However, this new version was destroyed during the Hideyoshi invasion in 1592, when the great stele of King T'aejo was also damaged.[263] In 1601 a further celestial globe was fashioned,[264] but no information is available on its construction or duration of use. Although Korea was a vassal of China during the Yi dynasty, as it had been at earlier periods, there does not appear to be any direct evidence that Chinese star maps or globes reached Yi Korea before the era of the Jesuit astronomers.

The Jesuit Contribution

Celestial cartography in China during the last years of the Ming dynasty and much of the subsequent Qing owed a great deal to the influence of missionaries of the Society of Jesus.[265] Many of these men were skilled astronomers, and they used their knowledge "to arouse the intellectual curiosity of the Chinese and to interest them in the doc-

261. Needham et al., *Heavenly Records*, 94 (note 5).

262. *Sejong sillok*, chap. 77, translated by Needham et al., *Heavenly Records*, 74–75 (note 5).

263. Jeon, *Science and Technology in Korea*, 67–68 (note 5).

264. *Sejong sillok*, chap. 77, translated by Needham et al., *Heavenly Records*, 100 (note 5).

265. This remark, of course, also applies to other branches of astronomy, and to science in general.

trines of the West."[266] Indeed, several Jesuits attained the office of astronomer royal at the Qing court. So great was their impact on celestial cartography in both China and Korea that no significant star chart produced in either country after 1600 (until the spread of modern knowledge in the twentieth century) is free of Jesuit influence. Although no member of the Society of Jesus reached Korea before the twentieth century, Korean ambassadors to China made contact with Western science as transmitted by the Jesuits, and copies of a number of star maps showing European influence found their way to the "Hermit Kingdom" (Korea).

In 1583 the Italian scholar Matteo Ricci became the first member of the Society of Jesus to enter the Chinese mainland. Ricci eventually (in 1601) settled at Beijing, the capital, dying there in 1610. Although not specifically an astronomer, Li Madou (as Ricci became known) profoundly impressed the Chinese with his knowledge of Western astronomy, for example, in eclipse prediction and calendrical science. The era of direct Jesuit influence on the course of Chinese astronomy lasted from the pioneering efforts of Ricci until 1773, when the Society of Jesus was temporarily disbanded by Pope Clement XIV.[267] Later Roman Catholic missionaries held the office of astronomer royal until 1826, but they never matched the achievements of their Jesuit predecessors. By this time, however, Chinese astronomy was irrevocably opened up to Western ideas.

In the field of uranography, the Jesuit astronomers made several important advances over contemporary Chinese methods of mapping the night sky. As well as measuring stellar coordinates with considerably higher precision than had ever been achieved previously in China, the missionaries introduced the first detailed knowledge of stars in the south circumpolar region.[268] They also established the Western system of grouping stars into six classes of brightness (or magnitude), which had its origin in ancient Greece; hitherto Chinese astronomers had shown little concern with the marked range of brightness among the stars visible to the unaided eye. Despite these and other European innovations (e.g., ecliptic coordinates), the Jesuits did not attempt to replace the traditional Chinese asterisms with Western constellations, although they charted many additional stars. The first telescope constructed in China was made by Jesuits in 1631, and several similar instruments were brought from Europe soon afterward,[269] but the telescope never found favor among traditional Chinese and Korean official astronomers, and—like Johannes Hevelius in Europe—the Jesuits themselves preferred a sighting tube rather than a telescope for measuring star coordinates.

Matteo Ricci is known to have constructed a number of astronomical spheres and globes made of copper and iron,[270] but neither the instruments themselves nor descriptions of them appear to have survived. Ricci several times sent messages to Rome asking that astronomers be sent to China, particularly to help reform the calendar, which had last been revised by Guo Shoujing as long ago as 1280. It was not until 1630 (twenty years after Ricci's death) that his hope was realized when the German Johann Adam Schall von Bell (1592–1666, Chinese name Tang Ruowang) and the Italian Giacomo Rho (1593–1638, Chinese name Luo Yagu), two Jesuits skilled in astronomy, reached Beijing.

Not long afterward, the Christian convert Xu Guangqi (1562–1633), who was director of calendar reform in the Ming government, published several small star maps and presented them to the emperor Sizong (1628–45). Xu Guangqi (also known as Paul Xu), a distinguished scholar, had been a close friend of Ricci's. The charts he produced incorporated Western innovations, but—as Xu himself appreciated—they were too small to represent the stars accurately;[271] the largest was only about fifty centimeters in diameter. Original prints of two of these charts, on paper, are preserved in the Vatican Library, titled *Jianjie zong xingtu* (General map of the visible stars) and *Huangdao zong xingtu* (Two general maps of the stars relative to the ecliptic).[272] A third chart by Xu bore the caption "Chidao liang zong xingtu" (Two general maps of the visible stars relative to the equator). This is printed in the encyclopedia *Chongzhen lishu* (Calendar treatise of the Chongzhen reign period, 1635), produced by Schall von Bell and his Jesuit colleagues. A fourth sectional map is titled *Huangdao ershifen xingtu* (Map of the stars relative to the ecliptic in twenty parts) and is preserved at the Palace Museum in Beijing. Brief descriptions of the first three charts follow.[273]

The largest chart, *Jianjie zong xingtu*, has an external diameter of fifty-seven centimeters and an internal diameter of fifty-four centimeters.[274] It depicts the whole of the visible sky on a polar (stereographic) projection down

266. This apposite quotation is from Pasquale M. d'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," *Monumenta Serica* 18 (1959): 328–59, quotation on 328.

267. The order was reestablished by Pope Pius VII in 1814.

268. Previously, only a few southern constellations had been mapped by the Chinese (see above).

269. Pasquale M. d'Elia, *Galileo in China: Relations through the Roman College between Galileo and the Jesuit Scientist-Missionaries (1610–1640)*, trans. Rufus Suter and Matthew Sciascia (Cambridge: Harvard University Press, 1960), 41.

270. *China in the Sixteenth Century*, 169 (note 198).

271. D'Elia, "Double Stellar Hemisphere," 347 (note 266).

272. Biblioteca Apostolica Vaticana, MS. Barberini, Orient. 151/1c, 151/1d (a copy of 1c), and 151/1e. A print of the first of these charts is also in the Bibliothèque Nationale, Paris.

273. See also Pan, *Zhongguo hengxing guance shi*, pls. 58–60 (note 7).

274. D'Elia, "Double Stellar Hemisphere," 338 (note 266).

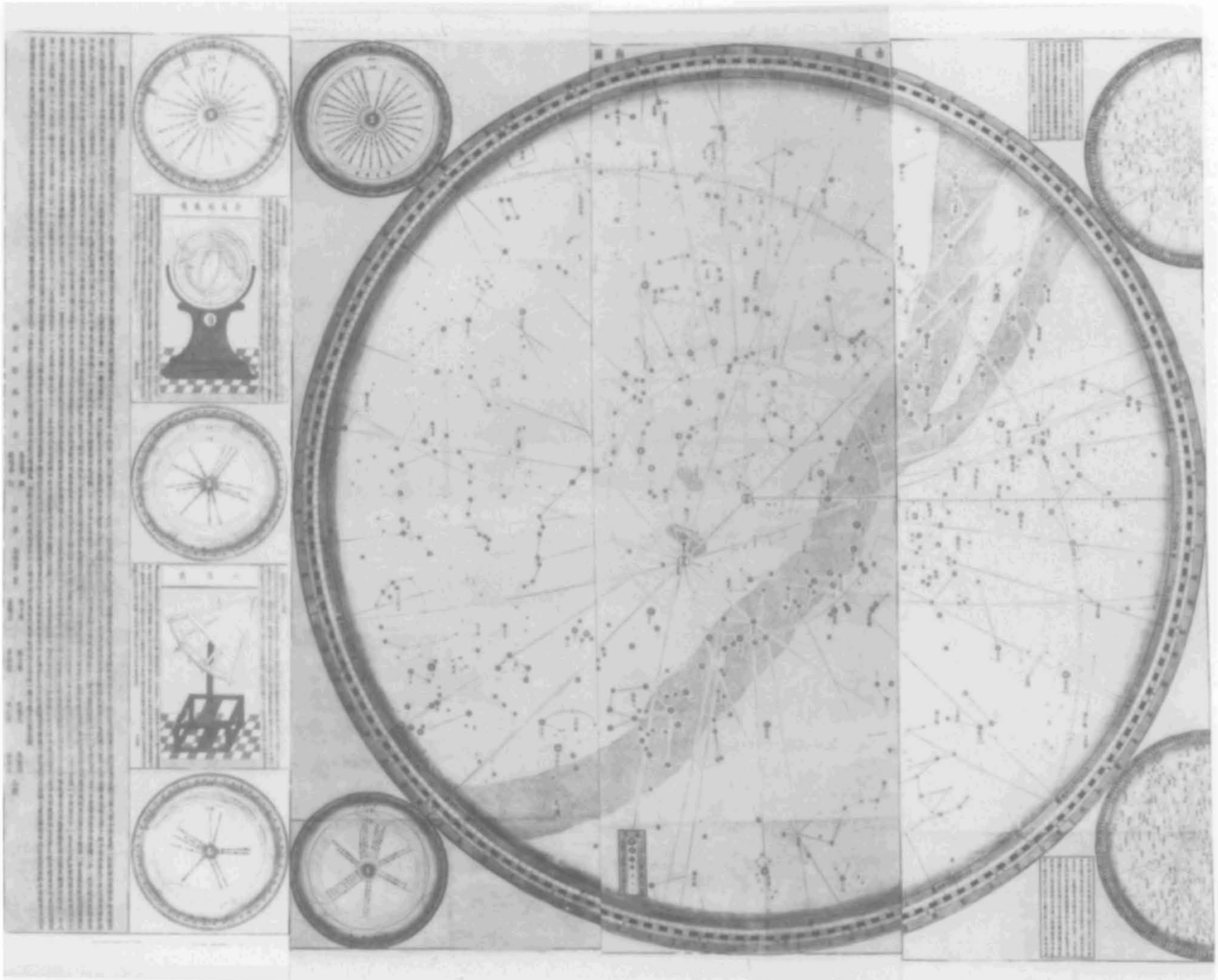


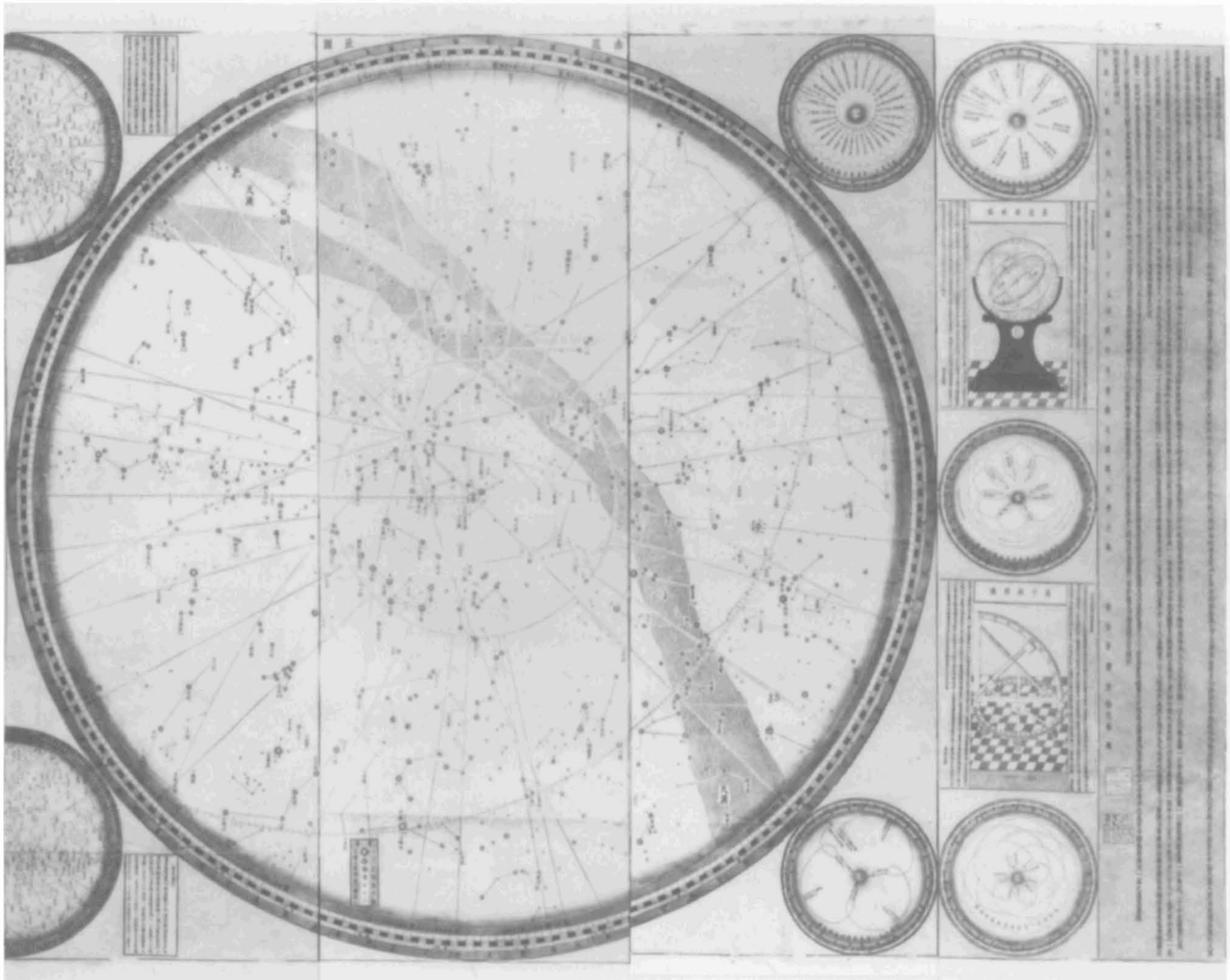
FIG. 13.39. SECTION OF SCHALL VON BELL STAR MAP, 1634, SHOWING STARS SOUTH OF THE CELESTIAL EQUATOR. This is part of a print similar to that shown in figure 13.40. Stars are grouped into six magnitudes on this equatorial chart, which is on a polar (stereographic) projection. Note the ecliptic pole and the boundaries of the zodiacal signs (shown as arcs).

to about 50° south declination and closely resembles a traditional Chinese chart. Stars are grouped into the characteristic patterns of antiquity, and there is little or no attempt to denote magnitude. The Milky Way is clearly marked. Constellations are individually named, but information on the chart is so crowded—especially toward the center—that the whole effort is of little practical use. The celestial equator, ecliptic, and circle of constant visibility are shown, along with the boundaries of the lunar lodges (denoted by radial straight lines extending from the circle of constant visibility to the edge of the chart). There appears to be no information on the number of stars depicted, but it is at least comparable with the standard tally of approximately 1,460.

The two smaller charts each depict the whole of the night sky in two separate hemispheres, bounded either by the ecliptic or by the celestial equator. Precise dimensions are available for the Vatican print: each hemisphere has an external diameter of twenty-nine centimeters and internal diameter of twenty-two centimeters.[275] The maps of the southern sky are probably the earliest surviving examples from China that delineate the full course of the Milky Way (as well as showing the Magellanic Clouds) and that represent more than a handful of constellations in the south circumpolar region; some twenty asterisms are depicted in this zone. The lunar lodge boundaries are not marked. Each hemisphere is drawn on a polar (stereographic) projection, a refinement that seems scarcely necessary on such a small scale.

The hemispheres on the *Huangdao zong xingtu* are

275. D'Elia, "Double Stellar Hemisphere," 338 (note 266).



Size of the entire original: ca. 170 × 450 cm. By permission of the Biblioteca Apostolica Vaticana, Rome (MS. Barberini, Orient. 149). Photograph courtesy of Pan Nai.

centered on the appropriate (north or south) ecliptic pole, and each extends to the ecliptic. The celestial equator is not shown. Although stars are grouped into the traditional asterisms, they are represented by symbols of six different sizes to indicate magnitude. Certain nebulas (*qi*) are also marked. The limits of the twelve zodiacal signs are delineated as equally spaced radial lines extending from either pole to the ecliptic.

The astrography on the "Chidao liang zong xingtu" closely resembles that on the ecliptic maps. These maps are centered on the appropriate (north or south) celestial pole, and each extends to the celestial equator. The ecliptic is shown, and the boundaries of the zodiacal signs are depicted as arcs radiating from the ecliptic pole to the edge of each chart. In addition, each chart is divided into twelve equal sectors by radial lines extending from either celestial pole to the equator. Two of these lines pass through the equinoctial points.

In 1628, Xu Guangqi revised the determinative stars of three lunar lodges: Zuixi, Kui, and Mao. In each case he selected brighter neighboring stars. The reference star of Zuixi was changed from φ′ Ori to λ Ori, that of Kui from ζ And to η And, and that of Mao from 17 Tau to η Tau. No similar alteration appears to have occurred at any previous time in Chinese history. However, Xu did nothing to solve the difficulties arising from the disappearance of the lodge Zuixi. Always the narrowest lodge, this had gradually narrowed owing to precession and had reached zero width during the Yuan. Soon after Xu's revision the situation was rectified by Schall von Bell,[276]

276. Pan, *Zhongguo hengxing guance shi*, 348 (note 7).

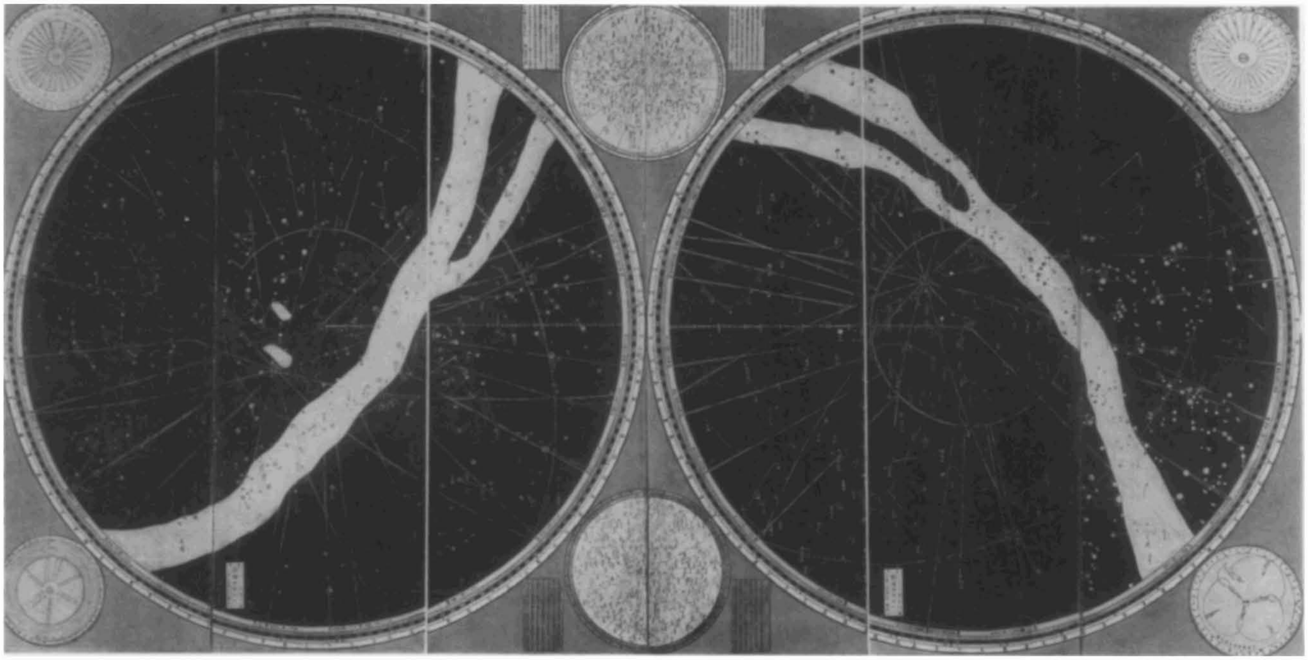


FIG. 13.40. 1634 STAR MAP BY SCHALL VON BELL, NOW IN BEIJING. This colorful print (gold stars on a blue background) is said to have been presented to the last Ming emperor. In all, 1,812 stars are depicted, as well as the Milky Way and Magellanic Clouds.
Size of the original: 1.6 × 4.2 m. First Historical Archives of China, Palace Museum, Beijing. Photograph from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 16.

who took the bold step of reversing the order of the lodges Zuixi and Shen so that Zuixi now became the twentieth *xiu* and Shen the twenty-first. As a result, the width of Shen was reduced from eleven degrees, forty-four minutes to only twenty-four minutes, while Zuixi acquired an angular extent of eleven degrees, twenty-four minutes. The long-term effect of precession was to slowly increase the width of Shen so that there was no risk of its disappearing.

Not long before his death in 1633, Xu Guangqi initiated the production of a larger-scale map of the night sky, showing both hemispheres. This extensive project, which involved redetermining the coordinates of a large number of stars, was undertaken by Schall von Bell, Rho, and several Chinese scholars, including Xu himself. It was completed the following year. The chart was engraved on wooden blocks in eight sections, each measuring 1.6 by 0.5 meters (fig. 13.39). Composite prints, 4.2 by 1.6 meters, were suitable for screen or wall mounting. In an accompanying preface, the title of the work is given as *Huangdao nanbei liang zong xingtu* (Two general maps of the stars south and north of the equator). A print on paper in eight separate sections is preserved in Beijing (fig. 13.40). This is reported to have been presented to the emperor Sizong (the last Ming ruler) by Schall von Bell.[277] Other copies of similar dimensions, printed on paper, are in the Vatican Library (two examples), at the Bibliothèque Nationale, Paris (two examples), and at the Consiglio Nazionale di Ricerche in Bologna.[278] The Beijing print depicts the background sky as dark blue and the Milky Way as white stippled with black; individual stars are gilded. One of the Vatican prints is attractively colored: the sky is shown in pale blue, and the Milky Way and stars are gilded. This copy was originally presented to the Grand Secretariat of the last Ming emperor. Both of these presentation copies are in a fine state of preservation. The other surviving prints in Rome, Paris, and Bologna are more basic; they are devoid of color and are on ordinary Chinese paper. The Paris and Bologna prints are in good condition, but the monochrome Vatican version is much faded.[279]

277. However, Pan, *Zhongguo hengxing guance shi*, 354–55 (note 7), asserts that the print now in the Palace Museum is of early Qing origin (ca. 1650).

278. D'Elia, "Double Stellar Hemisphere," 337 (note 266), Pan, *Zhongguo hengxing guance shi*, 354 (note 7), and Pan Nai, "Shiqi shiji chu shijie shouqu yizhi di heng xingtu" (A unique star map of the early seventeenth century), *Kexue* 42 (1990): 275–80.

279. On the Beijing version and the presentation copy in the Vatican, see *Zhongguo gudai tianwen wenwu tuji*, 16 and 101 (note 6), and d'Elia, "Double Stellar Hemisphere," pls. I and II (note 266). Pan is of the opinion that the Vatican presentation copy is the oldest surviving print. For example, it contains the names of all ten compilers, whereas the Beijing version carries only the name of Schall von Bell. Pan also bases his argument on coloring and other details, see Pan, "Shiqi shiji

In general, the various prints that are now in Beijing, Rome, Paris, and Bologna differ mainly in medium and color. On each example, the inner six sections are mainly taken up by two circular maps of the constellations, each 1.55 meters in diameter; one of these covers the Northern Hemisphere and the other the Southern Hemisphere. Explanatory prefaces, written by Xu Guangqi and Schall von Bell, are contained in the two outer sections. Additional small diagrams occupy much of the remaining space. Most of these illustrations depict planetary movements and certain astronomical instruments, but two small planispheres—each forty-three centimeters in diameter—chart the stars visible from northern China. One of these maps is centered on the celestial pole, the other on the ecliptic pole.

The two large hemispheres extend from either the north or the south celestial pole to the equator, so that the whole of the sky is represented. In his accompanying preface, Xu Guangqi explains the reason for including south polar constellations:

> In the southern hemisphere beyond the visible stars there are the stars in the zone of invisibility near the pole. These stars do not figure on the old Maps. But, though they are not directly visible from our various provinces, they are all visible from the coast down to Malacca. These parts belong to the sphere of sovereignty of our country; how can the stars visible there be excluded?[280]

Each chart is accurately drawn on a polar (stereographic) projection for the epoch 1628. The basic form resembles the twin equatorial maps of Xu Guangqi. Thus the stars are grouped into traditional Chinese asterisms, and the full circuit of the Milky Way is shown (together with the Magellanic Clouds). The ecliptic is marked, at declination close to 23.5°, and the boundaries of the twelve signs of the zodiac are represented by arcs extending from the ecliptic pole to the edge of each chart. Stars are classified into six magnitudes, according to the size of the symbol. In addition, the circles of constant visibility and invisibility (at 36° north and south declination) are depicted, and the boundaries of the lunar lodges are shown as radial lines extending to the edge of the chart. The periphery of each hemisphere is graduated into both ordinary degrees and *du*. A number of telescopic nebulas are also represented.

In all, 1,812 naked-eye stars are depicted, considerably more than the customary 1,460 or so shown on indigenous Chinese charts. In his accompanying explanation Schall von Bell states that of the total number of stars represented, 16 are of the first magnitude, 67 of the second, 216 of the third, 522 of the fourth, 419 of the fifth, and 572 of the sixth. Most of the additional stars are included in the region of sky visible from northern China, and he emphasizes that earlier Chinese star charts were far from complete for this zone. The remaining excess stars (126) are grouped in twenty-three asterisms in the south circumpolar region. Schall von Bell remarked that "because hitherto [the stars] were not combined into figures, they bore no name; therefore words transliterated from their original [Western] names have been used here."[281] In practice, some of the Chinese names of these groups are direct translations of their Western equivalents: for example, Fire Bird (Phoenix) and Triangular Shape (Triangulum). There are several obvious differences, however.

Unpublished measurements I have made on the two charts reveal that the stars are accurately positioned—typically to within a small fraction of a degree. The whole work was a remarkable pioneering effort; it was undoubtedly the most complete and accurate representation of the night sky produced in China up to that date. Later charts, compiled during the Qing dynasty, display even more stars, but the compilation by Schall von Bell is truly a landmark in Chinese astral cartography.

When the Manchus conquered China in 1644, Schall von Bell became the first astronomer royal of the new Qing dynasty. He was deposed twenty years later, and a Chinese astronomer was appointed in his place. Schall von Bell died in 1666. Soon afterward it became apparent that his successor lacked competence, and in 1667 the Belgian Jesuit Ferdinand Verbiest (1623–88, Chinese name Nan Huairen) became the new astronomer royal, a position he held until his death in 1688. Roman Catholic missionaries continued to serve as astronomer royal until 1826, when they were expelled by the emperor Xuan Zong (r. 1821–50) as part of a general suppression of Christianity in China.

By the Qing dynasty, the number of surviving star maps and celestial globes escalated to such a degree that it would take a separate essay to describe them in any detail. However, among major Qing artifacts I might mention maps and globes produced as the result of (a) a revision of Schall von Bell's catalog in 1672–73 by Verbiest; (b) a detailed sky survey in 1744–52 by Ignatius Kögler (1680–1746, Chinese name Dai Jinxian) and his successors; and (c) a further survey in 1842–45 by native Chinese astronomers.

Verbiest made revised measurements of star positions and also added a small number of previously uncharted faint stars. His revised catalog listed 1,876 stars visible

chu shijie shouqu yizhi di heng xingtu" (note 278). I am grateful to the Consiglio Nazionale di Ricerche for providing large-scale photographs of the print that is on display at their Bologna office.

280. Translated by d'Elia, "Double Stellar Hemisphere," 348 (note 266).

281. Translated by d'Elia, "Double Stellar Hemisphere," 356 (note 266).

FIG. 13.41. FERDINAND VERBIEST WITH HIS CELESTIAL GLOBE. Ferdinand Verbiest, who was astronomer royal in China from 1667 to 1688, is shown dressed as a Chinese official in this mid-nineteenth-century Japanese print. Also shown are his sextant and celestial globe.
Size of the original: 37.5 × 26 cm. By permission of the British Museum, London.

to the unaided eye. An investigation of the accuracy of the coordinates of the determinant stars of the twenty-eight *xiu* indicates remarkably high precision. Positional errors seldom exceeded one arc minute.[282] The results of Verbiest's work, including detailed maps of the whole sky, were published in 1674 in his *Yixiangzhi* (Description of astronomical instruments). In the previous year, he had cast in bronze a large celestial globe displaying these stars. This globe, "six *chi*" (roughly 1.5 m) in diameter, was one of the many new instruments with which Verbiest equipped the imperial observatory at Beijing. All these instruments were constructed for unaided-eye observations using sighting tubes. After the Boxer Rebellion in 1900, the celestial globe and four other instruments were transported to Berlin, where they were placed in the royal garden at Potsdam Palace. They were not returned to China until 1921. They are still in almost pristine condition after more than three centuries in the open air and can be viewed at their original site—the Ancient Observatory in Beijing (figs. 13.41 and 13.42).[283]

The extensive survey begun in 1744 under Kögler's direction took eight years. During that time, as many as 3,083 stars in three hundred constellations were charted. At the commencement of the project, Kögler was assisted by another Jesuit, August von Hallerstein (1703–74). After Kögler's death in 1746, von Hallerstein succeeded him as Qing astronomer royal, and two other Jesuits, Anton Gogeisl (1701–71) and Felix da Rocha (1713–81), helped him complete the work. The star catalog and associated astral charts were published in 1757 in the *Yixiang kaocheng* (Treatise on astronomical instruments). These accurately drawn equatorial charts are on a polar (equidistant) projection. Rather surprisingly, there is no attempt to represent magnitude; all stars are denoted by dots of equal size. Excellent replicas of these maps were published near the turn of the present century (figs. 13.43 and 13.44).[284] In 1723 Kögler had produced an ecliptic star map showing both hemispheres. Several copies of this work are known to exist.[285]

A new survey begun in 1842, although undertaken by Chinese astronomers, still made use of the old Jesuit instruments. This task, under the direction of Jing Zheng, lasted two and a half years (until 1845), and all together 3,240 stars were charted. It was published as the *Yixiang kaocheng xupian* (Sequel to the Treatise on astronomical instruments) and contains detailed equatorial star maps for both hemispheres drawn on a polar stereographic projection.[286]

The last significant example of Qing celestial cartography dates from 1903, only a few years before the downfall of the dynasty. This is in the form of a large bronze celestial globe (.96 meter in diameter) that displays 1449 stars in the traditional constellations (fig. 13.45). It was built to replace the globe constructed by Verbiest that had been transported to Germany in 1900. The Qing globe is still in excellent condition and can be viewed at Purple Mountain Observatory, Nanjing. On the foundation of the republic, only eight years after the globe was installed, the way was clear for the introduction of astral charts depicting only the Western constellations.

There seem to have been few significant astronomical

282. Pan, *Zhongguo hengxing guance shi*, 381 (note 7).

283. An excellent photograph is published in *Zhongguo gudai tianwen wenwu tuji*, 105 (note 6).

284. Tsutsihashi and Chevalier, "Catalogue d'étoiles," D1-D16 (note 4).

285. For example, Needham et al. have published a useful photograph of an engraving in a private London collection; see *Heavenly Records*, fig. 5.6 (note 5).

286. The *Yixiang kaocheng xupian* was published in Beijing, ca. 1845.

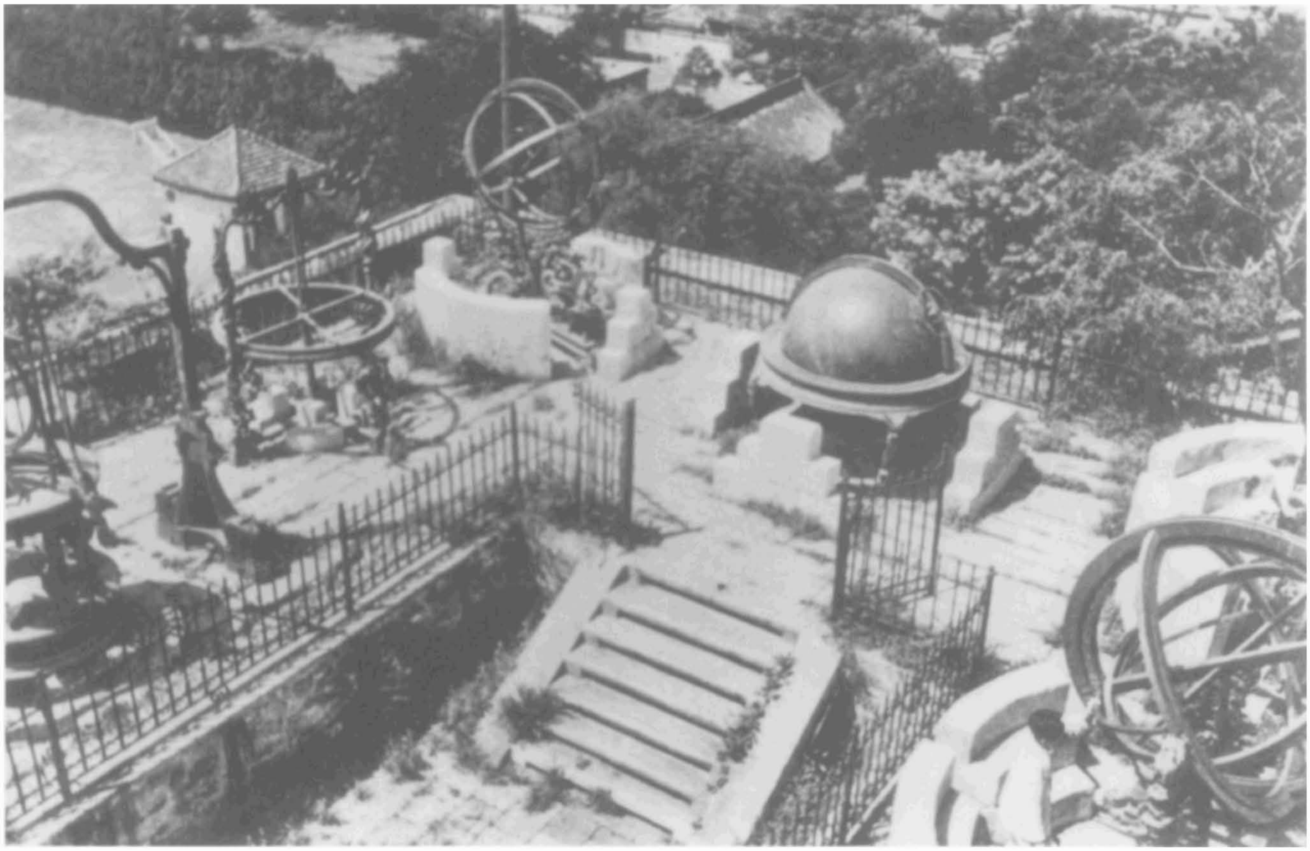


FIG. 13.42. VERBIEST'S CELESTIAL GLOBE IN BEIJING. One of the many instruments cast by Verbiest that can still be seen at the Ancient Observatory, Beijing, this celestial globe is still in almost pristine condition (above and right).
Diameter of the original: ca. 1.5 m. Ancient Observatory, Beijing. Photographs from Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo, *Zhongguo gudai tianwen wenwu tuji*, 104 and 105.

contacts between the Jesuit missionaries and Koreans during the Ming dynasty. In 1631, however, not long before the end of the Ming, the Yi ambassador Chŏng Tuwŏn returned to Korea from the Ming court with a number of books on astronomy and several scientific instruments. These acquisitions included a telescope, presented by the Portuguese Jesuit João Rodrigues, and an astronomical chart.[287] Shortly after the demise of the Ming dynasty in 1644, Crown Prince Sohyŏn of Korea, who had been held hostage at the Ming court, returned to his homeland bearing a number of gifts from Schall von Bell, including a celestial globe.[288] Not long afterward, in 1648, another Korean named Song Inyong stud-

287. Donald L. Baker, "Jesuit Science through Korean Eyes," *Journal of Korean Studies* 4 (1982–83): 207–39, esp. 219–20.

288. Needham et al., *Heavenly Records*, 178 (note 5).

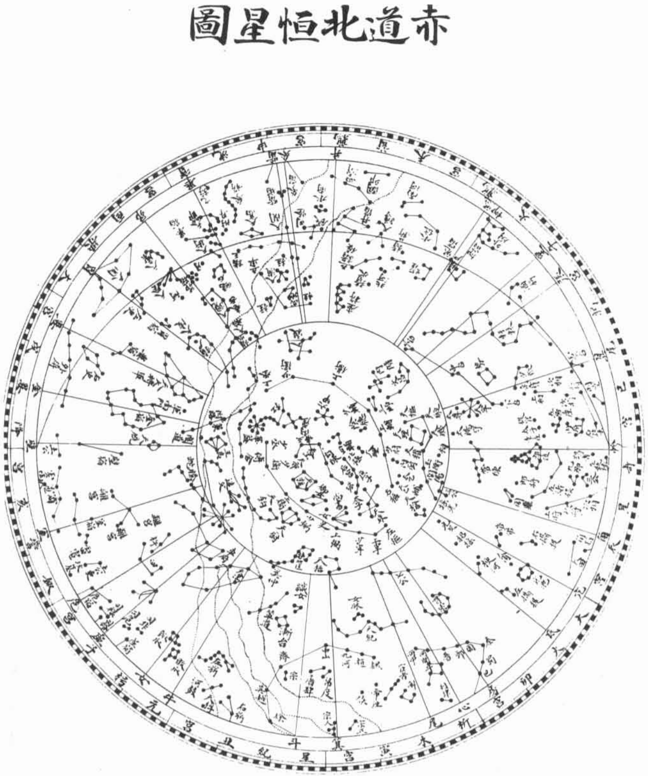


FIG. 13.43. REPLICA OF KÖGLER/VON HALLERSTEIN STAR MAP, 1757 (NORTHERN HEMISPHERE). This print forms a unit with figure 13.44 and depicts the night sky north of the celestial equator according to von Hallerstein. Both charts are produced for latitude 40°N, the latitude of Beijing. From P. Tsutsihashi and Stanislas Chevalier, "Catalogue d'étoiles observées à Pé-kin sous l'empereur K'ien-long (XVIII[e] siècle)," *Annales de l'Observatoire Astronomique de Zô-sè (Chine)* 7 (1911): I-D105, plates between IV and V.

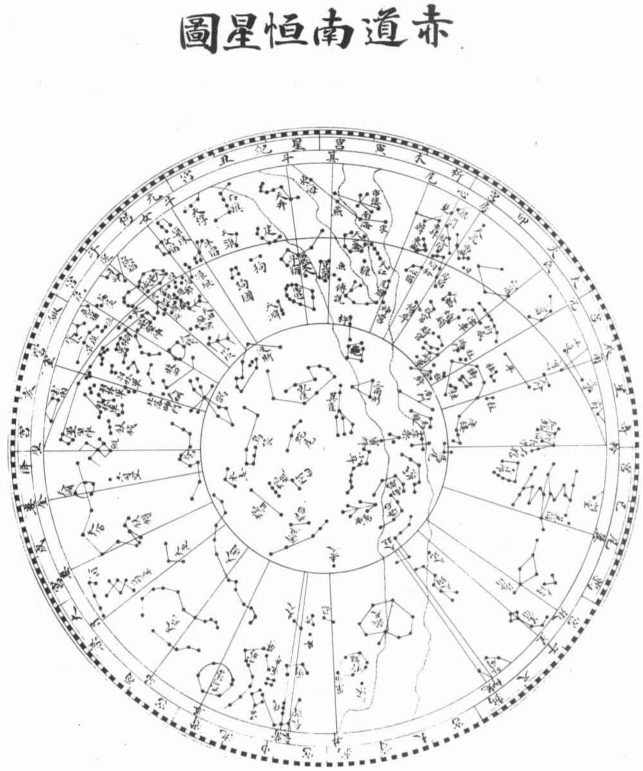


FIG. 13.44. REPLICA OF KÖGLER/VON HALLERSTEIN STAR MAP, 1752 (SOUTHERN HEMISPHERE). This is a print of one of two charts produced in 1757 by Jesuits including August von Hallerstein (see also figure 13.43). Unlike other Jesuit charts, there is no attempt to represent stellar magnitude. This equatorial chart is on a polar (equidistant) projection. From P. Tsutsihashi and Stanislas Chevalier, "Catalogue d'étoiles observées à Pé-kin sous l'empereur K'ien-long (XVIII[e] siècle)," *Annales de l'Observatoire Astronomique de Zô-sè (Chine)* 7 (1911): I-D105, plates between IV and V.

ied under Schall von Bell, and he brought back a large astronomical chart.[289] Unfortunately, nothing is known about the construction of either the globe or the charts acquired by various Korean travelers. Many years later, in 1708, the Yi Bureau of Astronomy produced a replica of the 1634 chart of Schall von Bell and presented it to King Sukchong. Like its Chinese equivalent, it is known to have displayed 1,812 stars.[290] Regrettably, no copy can be traced today.

A block print of a late eighteenth-century planisphere of unusual form is preserved in Seoul. This chart, titled *Honch'ŏn chŏndo* (Complete map of the celestial sphere), depicts the night sky visible from Korea on a polar (equidistant) projection.[291] Although the accompanying text states that there are 1,449 stars in 336 constellations, whereas the number of constantly invisible stars around the South Pole amounts to 121 in 33 constellations, the planisphere itself shows little evidence of Jesuit influence. For example, the south circumpolar region is not displayed (despite the remarks in the text), and there is little or no attempt to discriminate between stars of different brightness. The whole chart is divided into twelve equal sectors separated by radial lines that extend from the center of the chart to its edge. At the periphery these sectors are labeled as *ci*, but the positions are only approximate; two of these lines are incorrectly shown as passing through the equinoctial points.

An unusual feature—also found on a late sixteenth-century Ming astral map—is the representation of both the ecliptic and the celestial equator as offset circles. The centers of each of these circles are thirteen degrees from the center of the chart (which also corresponds to the center of the circle of constant visibility), yet the circles intersect at two points exactly 180 degrees apart (i.e., at

289. Needham et al., *Heavenly Records*, 178 (note 5).

290. *Chŭngbo Munhŏn pigo*, chap. 3 (note 223).

291. For a photograph, see Jeon, *Science and Technology in Korea*, fig. 1.4 (note 5).

FIG. 13.45. QING CELESTIAL GLOBE, 1903, AT NANJING. The last important example of Qing uranography, this large celestial globe was cast in bronze only a few years before the dynasty came to an end. It displays 1,449 stars in the traditional Chinese constellations. Diameter of the original: ca. 100 cm. Purple Mountain Observatory, Nanjing. Photograph courtesy of F. Richard Stephenson.

the equinoxes). As in the case of the Ming planisphere there is clear evidence of distortion of the constellations to accommodate this device.

Several Korean copies of Kögler's 1723 star map are preserved, two of them on screens.[292] One of these screens, dating from 1755–60, is now in Cambridge, England. This illustrates, in attractive colors, both the Kögler artifact and the 1395 planisphere of King T'aejo.[293] A block print of Kögler's map was made as late as 1834.[294] By this date, although a certain amount of nostalgia still surrounded the medieval planisphere of King T'aejo, serious Korean astrography was thoroughly influenced by Western innovations.

Concluding Remarks

Although it can be established that several constellations were recognized in China by the late second millennium B.C., knowledge of the early development of Chinese uranography is still fragmentary. It is convenient for us to divide the history of celestial mapping into four discrete eras. In the earliest of these periods, which extends from about 1300 B.C. to 100 B.C., there are no surviving star maps or catalogs. No more than about thirty constellation names are extant from this long interval: little more than the lunar lodges and the Dipper. In the second period, between about 100 B.C. and A.D. 700, there is evidence of extensive astral cartography, but in general existing star charts from this period portray only a few constellations. A number of important celestial maps have survived from the third period, between about 700 and 1600, especially from the later half of this interval. Finally, from about 1600 onward, all star charts of any significance reveal Western influence. The Jesuit astronomers introduced European techniques of mapping the sky, although they did not attempt to supplant the traditional Chinese asterisms with Western constellations.

In the ancient period, perhaps the most important recent discovery has been a list of all twenty-eight *xiu* inscribed on a chest dating from about 433 B.C. This is the earliest date at which the existence of the twenty-eight lodges can be established as an entity. Although arguments based on precession tend to suggest a much earlier date for the origin of the *xiu* (the third millennium B.C.), they remain unsupported by documentary evidence. It may well be that further archaeological excavations will shed new light on this or other problems. Archaeological discoveries of astronomical importance have been very haphazard, however, and this pattern seems likely to continue, at least in the near future.

Although few star maps survive from the period between about 100 B.C. and A.D. 700, historical records assert that many charts and celestial globes were produced at this time, and their loss is to be lamented. A number of contemporary star catalogs (notably that preserved in the *Xingjing*) and constellation lists are extant, and these indicate a high level of attainment reached by astral cartography. Replicas (several times removed from the original) of a Chinese star chart of the first century B.C. appear to be preserved in Korea. The configurations of some of the constellations on these copies (the earliest dating from 1395) differ considerably from those on medieval Chinese charts. A detailed investigation seems to be a matter of some urgency. The 1395 stele was held in such regard in Korea that all surviving Korean star maps from the pre-Jesuit period are replicas of it.

The Suzhou planisphere (engraved on stone in 1247) provides direct evidence of the considerable achievements of Song celestial cartography. Other notable star maps of the period, although now existing only in late copies, were originally produced by Su Song in 1094. These were the earliest known star maps to be printed in any part of the world. A colored star chart found at Dunhuang, possibly dating from the eighth century, although crude, is the sole survivor of its era. This chart displays the stars in three colors, recalling the groupings of antiquity. The groupings on the Dunhuang and Su Song star maps have much in common, and careful comparison between them may well shed new light on the whole question of the traditions ascribed to the "ancient schools." Unfortunately, a Ming copy of a celestial globe cast by the great Yuan astronomer Guo Shoujing disappeared early in the present century. If its whereabouts can be traced, it could provide an important missing link in the study of medieval Chinese celestial cartography.

Several of the star maps produced by Jesuit astronomers in China have been extensively studied; there is ample evidence that these were produced with consummate skill. As yet, no detailed investigations of several important Qing artifacts have appeared. These items include the bronze celestial globe cast by Ferdinand Verbiest in 1673 (now at the Ancient Observatory in Beijing), several colorful astral charts (preserved at the First Historical Archive of China in in the Palace Museum, Beijing), and the bronze globe of the stars cast as recently as 1903 (displayed at Purple Mountain Observatory). Evidently, much can still be written on Qing uranography.

292. Needham et al., *Heavenly Records*, 159–69 and 175 (note 5).
293. Good illustrations are in Needham et al., *Heavenly Records*, figs. 5.1, 5.3, and 5.5 (note 5).
294. Jeon, *Science and Technology in Korea*, 31 (note 5).