An Astrolabe by Muḥammad Muqīm of Lahore Dated 1047 AH (1637–38 CE)*

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Abstract

Astrolabe was the most important astronomical instrument in the medieval period. It became popular in the Indian subcontinent after the eleventh century. The production of astrolabes and celestial globes in the Indian subcontinent was dominated by Ustād Allāh Dād and his descendants in the second half of the sixteenth century and in the seventeenth century. Their astrolabes display a fine combination of geometrical precision, high level of metal craft and aesthetic beauty. Allāh Dād's descendants revolutionised the production of the celestial globes by casting them as single hollow spheres by the lost-wax process. About a hundred and twenty astrolabes and twenty-five globes made by this family are extant today in museums and private collections in India, Middle East, Europe and USA. In Pakistan, however, there are just two astrolabes made by Allāh Dād's grandson Muḥammad Muqīm are available. One is housed in the Lahore Museum and the other is kept in the Islamabad Museum. Nevertheless, these two astrolabes constitute an important national heritage and deserve to be studied in detail. The present paper offers a full technical study of an elegant astrolabe made by Muḥammad Muqīm in 1637, which is now preserved in the Islamabad Museum.

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Introduction

The astrolabe or more accurately the planispheric astrolabe is a two-

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dimensional representation of the celestial sphere. It was the most important astronomical instrument in the mediaeval period. The altitude of the sun can be measured with it in the daytime and the altitudes of several bright stars at night. With these values, time can be determined both during the day and at night. It can be used to solve a number of trigonometric problems.[1]

The principal components of the astrolabe are the main body, called mater, a perforated plate called rete on which the positions of several bright stars are marked and a set of plates prepared for different terrestrial latitudes so that travellers can use the astrolabe wherever they go. So a caravan from Xi'an (China) could travel to Samarqand, Iṣfahān, and up to Cairo or Makkah using the same astrolabe as a navigation device. When the rete is correctly placed upon the plate for the observer's latitude, its rotation around the centre simulates the movement of the stars around the pole.

In the rete, the points indicating the star positions are joined to the main frame by artistic traceries. There are also "blank pointers" which do not depict a star but which are necessary to give mechanical stability and a symmetrical look to the rete. The artistic ambience of an astrolabe, its light weight and a manageable size made it not only an item worthy of kings but also a handy instrument for the travellers. The position of the celestial objects could either be measured for that instant or calculated for any time of the year. This facilitated the *mu'adhdhīn* and the muwaqqit in the mosque to call for the prayers. It equally suited a Jyotishi interested in *muhurat* (auspicious time for an event) or an astrologer *nujūmī* casting the horoscope. The accuracy of the readings was adequate for a mathematician to solve problems of spherical trigonometry and a surveyor to calculate the height of a hill or a distant tower of the fort. A ready reckoner for a geographer and a measuring device for an astronomer, the astrolabe showed a variety of facets to its divergent users. It is a fine combination of arithmetic and geometrical models. The tables, graphical lines, and nomograms represent the arithmetic model and the heavenly motion using rete, plates and pin typify the geometrical model.

01. History of the Astrolabe

The astrolabe was invented in Greece but attained its fullest perfection in the Islamic world. It is not known precisely when it was invented and by whom? The construction of the astrolabe is based on stereographic projection, which

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[1] See Willy Hartner, "The Principles and Use of the Astrolabe," in *Oriens, Occidens. Ausgewählte Schriften zur Wissenschafts- und Kulturgeschichte. Festschrift zum 60. Geburtstag.*, ed. Willy Hartner (Hildesheim: G. Olms, 1968), 287–311; James E. Morrison, *The Astrolabe* (Rehoboth Beach, DE: Janus, 2007).

is said to have been invented by Hipparchus who lived in the second century BC. Along with the Greek sciences, the astrolabe was adopted by the Islamic world in the eighth century CE.[2]

The adoration for knowledge and religious requirements like the direction of *qiblah*, times of prayers and start of the month of fasting promoted astronomy in the Islamic world. The observational astronomy was a forte of Islamic sciences. The Muslim interest in Greek sciences introduced them to this special instrument called *ἀστρολάβος* in Greek, *asṭurlāb* or *asṭurlāb* in Arabic and Persian respectively and "astrolabe" in English. According to the famous historian Isḥāq b. al-Nadīm [d. 995 CE], astrolabes were quite popular already before Abbasids but were extensively made in the reign of Ma'mūn al-Rashīd (r. 813–833 CE).[3] Many renowned scholars like al-Khawārizmī [780–850 CE], *Māshā' Allāh b. Atharī* [740–815 CE] and al-Bīrūnī [973–1048 CE] wrote valuable texts on the construction of the astrolabe and its use. The treatise of Naṣīr al-Dīn al-Ṭūsī (1201–1274 CE) on the astrolabe became quite popular in India.[4] The science and art of astrolabe making became a widespread activity in the Muslim world. Important contributions were also made in Andalusia, such as the universal astrolabe designed by Abū Isḥāq Ibrāhīm b. Yaḥyā al-Zarqālī (1029–1087 CE).

From Andalusia, the astrolabe spread to Europe where it was adopted with great enthusiasm and several books were written on it in Latin. More importantly, many of the names which are used for the fixed stars today are derived from the Arabic names engraved on the astrolabes. For example, *ra's al-ghūl* is known today as "Algol," *al-dabarān* as "Aldebaran," *al-fard al-shujā'* as "Alphard" and so on.[5] From the Islamic world, the science of the astrolabe spread westwards up to England and eastwards up to India.

In the Islamic world, in particular, the astrolabe enjoyed a great prestige. Its popularity spread outside the confines of observatories and was mentioned by poets as well. The famous poet Jalāl al-Dīn Rūmī (1207–1273 CE) has allegorically mentioned astrolabe as an instrument of measurement in his *mathnavī*. He says,

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[2] Sharon L. Gibbs and George Saliba, *Planispheric Astrolabes from the National Museum of American History* (Washington, D.C.: Smithsonian Institution Press, 1984), 12.

[3] Isḥāq b. al-Nadīm, *Kitāb al-Fihrist*, trans. Muḥammad Isḥāq B͟haṯṯī (Lahore: Idārah-i Thaqāfat-i Islāmiyyah, 1990), 656.

[4] Ibn al-Zargalluh Muḥammad b. Muḥammad Ḥasan Ṭūsī, *Risālah Bīst Bāb dār Ma'rifat-i Usṭurlāb* (Tehran: 1335 AH), no. 307; Manuscript in University of the Punjab Library, Lahore, MFN No. 87530, Ph iii, 261.

[5] See Table 1 below; in the last column the modern star names which are derived from Arabic are marked with an asterisk (*).

Pas tura ʿaqlat chū usṭurlāb būd Zāṇ badānī qurb-i khūrshīd-i wujūd[6]
Hence you and your intellect are like the astrolabe: by this means you may know the nearness of the Sun of existence.[7]
At another place he writes,

ʿillat-i ʿāshiq ziʿillathā judā ast *ʿishq usṭurlāb-i asrār-i khudā ast*[8]

The lover's ailment is separate from all other ailments: love is the astrolabe of the mysteries of God.[9]

The earliest extant astrolabes made in the Islamic world are from the tenth century. According to L. A. Mayer, there were more than one hundred and thirty astrolabe makers in the Islamic world (called *aṣṭurlābī*) who showed their passion for this instrument.[10] Numerous variations and innovations were made in the thousand years of their glory. This led to many types of astrolabes, spherical, linear and planispheric etc. But the spherical and linear astrolabes are theoretical curiosities and have no practical relevance. The most practical and therefore most popular was the planispheric astrolabe, more correctly the "planispheric northern astrolabe" (*shamālī saṭḥī aṣṭurlāb*).

Each culture area, where the astrolabe was cultivated, developed its own technical and aesthetic style, to discuss which is beyond the scope of this paper. However, three broad categories can be mentioned, viz., the European style, the style of the Western Islam (*Maghrib*) and that of Eastern Islam (*Mashriq*).[11] A few differences may be mentioned here. The European astrolabes have a rotating arm in front of the astrolabe on top of the rete besides the alidade at the back. They do not have the cotangent scale at the back which is more relevant to Muslims for determination of prayer times.[12] The astrolabes made in the *Maghrib*, the *Mashriq* and Europe differ in the style of throne (*kursī*); a simple, undecorated throne being more popular in the *Maghrib* and Europe whereas ostentation was preferred in the *Mashriq*.[13] Within the *Mashriq* there are distinct differences in Persian and Indian astrolabes. The Persian astrolabes have solid thrones with surface decorations whereas those made in India have generally perforated thrones. In Indian

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[6] پس ترا عقلت چو اصطرلاب بود زان بدانی قرب خورشید وجود

[7] Reynold A. Nicholson, ed., *The Mathnawí of Jalálud'dín Rúmí*, (Lahore: Sang-e-Meel Publications, 2004), 474.

[8] علت عاشق ز علتها جدا ست عشق اصطرلاب اسرار خدا ست

[9] Nicholson, *The Mathnawí of Jalálud'dín Rúmí*, bk. 1, line 110, p. 10.

[10] L. A. Mayer, *Islamic Astrolabists and Their Works.* (Genève: Albert Kundig, 1956).

[11] For a comparative analysis of these three styles, see Gibbs and Saliba, *Planispheric Astrolabes from the National Museum of American History*, 22–60.

[12] Ibid., 224 n. 29.

[13] Ibid., 17.

astrolabes, the rete contains more star pointers. The design of the back also differs in Persian and Indian astrolabes. In Persian Safavid astrolabes, the horizontal and vertical parallels in the upper left quadrant as also the arcs of the signs of the zodiac in the upper right quadrant are stereographically projected while in the Indian astrolabes these are equidistant. In Indian astrolabes, a graph of the meridian altitude of the sun is plotted upon the arcs of the zodiac signs, which is not the case in Persian astrolabes. Finally, in the Persian Safavid astrolabes, the entire surface is filled with fine ornamental engraving, the letters and numerals being engraved in high relief against a patterned background. In contrast, the engraving on the Indian astrolabes is plain and austere.[14]

02. The Astrolabe in India

Many types of instruments were used by astronomers in India prior to the arrival of Muslims. The classical *Siddhāntas*, Sanskrit texts on Indian astronomy dating back to fifth century CE, included methods of observations using instruments.[15] Astrolabe was introduced probably by Abū 'l-Rayḥān Muḥammad b. Aḥmad al-Bīrūnī (973–1048 CE) in India in the early eleventh century.[16] A famous poet Abū 'l-Ḥasan Yamīn al-Dīn Khusrau (1253–1325 CE), known as Amīr Khusrau, gives a brief account of astrolabe in his *Āʾīnah-i Sikandarī*. He has mentioned rete and alidade and the latter use for sighting sun showing his knowledge and the popularity of this instrument in his times.[17]

> *Az āṇ tang sūrākh bīnish farōz shudash rāz-i khurshīd rōshan chū rōz*[18]
> From the small hole (in alidade) the sight becomes clear (and) the secret of the sun becomes obvious like the daylight.

Fīrūz Shāh Tughlaq (r. 1351–1388 CE) took a keen interest in astronomy and patronised the translation of Sanskrit texts into Persian and Arabic and Persian texts into Sanskrit. He promoted manufacturing of astrolabes starting

[14] Sreeramula Rajeswara Sarma, "The Lahore Family of Astrolabists and Their Ouvrage," *Studies in History of Medicine and Science* 13, no. 2 (1994): 207; reprinted in: Sreeramula Rajeswara Sarma, "The Lahore Family of Astrolabists and Their Ouvrage," in *The Archaic and the Exotic: Studies in the History of Indian Astronomical Instruments* (New Delhi: Manohar, 2008), 199–222.

[15] Yukio Ōhashi, "Astronomical Instruments in Classical Siddhāntas," *Indian Journal of History of Science* 29, no. 2 (1994): 155–314.

[16] Eduard Sachau, *Alberuni's India.*, vol. 1 (New Delhi: Munshiram Manoharlal, 1992), 136–37.

[17] Amīr, Khusro, *Āʾīnah-i Sikandarī,* comp. Muḥammad Saʿīd Aḥmad Fārūqī (Aligaṛh: Maṭbʿah Institute, 1917), 146–148.

[18] ازان تنگ سوراخ بینش فروز   شدش راز خورشید روشن چو روز

a new era in Indian astronomy.[19] Indians termed the astrolabe as *yantrarāja*, "king of instruments" because of its versatility. Mughal emperors were immensely interested in science, art and culture. The fervent effort on instrument making seen during Mughal period lasted until the middle of nineteenth century. More than two hundred and sixty-five astrolabes were produced in India during the period between sixteenth and eighteenth centuries. Out of these, some ninety astrolabes have Sanskrit inscriptions showing the synthesis of scientific traditions.[20]

03. Astrolabe Makers of Lahore

During the Mughal period, Lahore became the major centre of instrument making, a tradition that was kept alive till the nineteenth century. A family of astrolabists, headed by Ustād Allāh Dād Asṭurlābī Humāyūnī Lāhōrī (fl. ca. 1550) produced about 120 astrolabes.[21] This specialised work started during the reign of Mughal Emperor Humāyūn (r. 1530–1540 and 1555–1556). Allāh Dād's son Mullā Īsā and grandsons Muḥammad Muqīm and Qā'im Muḥammad followed by three grand-grandsons carried this tradition till the end of the seventeenth century. It has been argued that "in the entire history of scientific instrumentation in the Middle Ages there has been no other family comparable to this one in terms of the long continuous family tradition, the immense quantum of work produced the artistic and technical excellence of production and or in the innovations in design."[22]

Allāh Dād's grandson Muḥammad Muqīm was a very prolific astrolabe maker. The thirty-seven extant astrolabes made by him have dates between 1609 and 1659.[23] A rough estimate may place his year of birth around 1590. His astrolabes are considered masterpieces of metal craft with beautiful and matching patterns on the *kursī* and on the rete; they are at the same time geometrically very precise. He made the world's smallest astrolabe with a diameter of 43 mm and also the most elaborate zoomorphic astrolabe with a diameter 352 mm.[24] In 1994, Saifur Rahman Dar, former director of the

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[19] Sreeramula Rajeswara Sarma, "Sulṭān, Sūri and the Astrolabe," *Indian Journal of History of Science* 35, no. 2 (2000): 129–47; Sreeramula Rajeswara Sarma, *Astronomical Instruments in the Rampur Raza Library* (Rampur: Rampur Raza Library, 2003), 7.

[20] Sarma, "A Bilingual Astrolabe from the Court of Jahāngīr," *Indian Historical Review* 38, no. 1 (2011): 80.

[21] Sarma, "The Lahore Family of Astrolabists and Their Ouvrage," 1994, 205–24; Sarma, "The Lahore Family of Astrolabists and Their Ouvrage," 2008, 199–222.

[22] Sarma, "The Lahore Family of Astrolabists and Their Ouvrage," 2008, 199–200.

[23] Ibid., 205.

[24] Ibid., 212.

Lahore Museum, did an important survey of the astrolabes preserved in the museums of Pakistan.[25] According to him only two astrolabes of Muqīm are in Pakistan. An undated astrolabe by Muqīm is in the Lahore Museum (inventory number M-44–1) and a dated astrolabe was formerly in the National Museum of Pakistan, Karachi (inventory number N.M.1959–407). The dated astrolabe has now been transferred to the Islamabad Museum and is the subject of the present study.[26]

The Astrolabe made by Muḥammad Muqīm in 1047 AH

1.0. The Astrolabe in the Islamabad Museum

The brass astrolabe by Muḥammad Muqīm which is now preserved in the Islamabad Museum (inventory number ID 186) is one of the finest instruments, with all the components intact. The astrolabe is well preserved with negligible scratches and patina. All the components seem to have been made at the same time. According to the inscription engraved on the back, it was made in 1047 AH (1637–38 CE)

1.1 The Components of the Astrolabe

This astrolabe consists of the following components

- Mater (Latin = mother; Arabic, *umm*) is 256 mm in diameter and 375 mm in height.
- Rete (Latin = net or mesh; Arabic *shabakah*; or *ʿankabūt*, "spider") is 240 mm in diameter.
- Five plates (*ṣafā'iḥ,* plural of *ṣafīḥah*,), each with a diameter of 238 mm.
- Alidade (from the Arabic *al-ʿaḍādah;* Latin: radius) is 232 mm long and 20 mm wide with two holes (hole: *thuqbah*) each in the rectangular sighting plates.
- Ring (*ḥalqah*) attached to the throne (*kursī*) through a shackle (*ʿurwah*)
- A pin (*quṭb*) passing through the hole in the astrolabe and secured by a small washer (*fals*) and horse-shaped wedge (*faras*) in the front.

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[25] Saifur Rahman Dar, "Three Rare Astrolabes in the Collection of Lahore Museum and Lahore's Contribution towards Astrolabe-Making," *Lahore Museum Bulletin* 7, no. 1–2 (1994): 165–98, pl. I–X, figs. 1–3.

[26] It is listed as 2704 in Sharon L. Gibbs, Janice A. Henderson, and Derek J. de Solla Price, *A Computerized Checklist of Astrolabes* (New Haven, Conn.: Yale University Press, 1973).

Fig. 1 The Astrolabe made by Muḥammad Muqīm, Islamabad Museum: The Front

Fig. 2 Astrolabe made by Muḥammad Muqīm: All Componenets

1.2 The Suspensory Apparatus

In Islamic astrolabes, it is usual to have a triangular, decorated piece of metal (throne) between the circular body of the astrolabe and the ring that is used for suspending it in a vertical position. The throne may either be pierced or a flat type with inscriptions on it. The cultural interaction between medieval Iran and India influenced some of the design features of Indian astrolabes. One of the usual distinct features was the pierced *kursī* (throne) in Persian astrolabes (e.g., an astrolabe made by Ḥāmid b. Maḥmūd al-Iṣfahānī in 1152 CE.[27] In India, the astrolabes usually have pierced type throne, also called Indo-Persian style throne. The triangular throne of this astrolabe is 63 mm high with a base to height ratio of 2:1, giving it a balanced look. To the top of the *kursī* is attached a shackle through which passes a ring. The shackle and ring are so designed that the astrolabe can be suspended in a vertical place and turned all around. In the centre of the *kursī* are inscribed the following words in Persian (Nastaliq script): "Zi *Ghafūr maghfirat ummīd dāram.*" It can be translated as "I hope to be forgiven by the Forgiver."

1.3 The Front of the Astrolabe

The front (*wajh*) of this astrolabe has a circular raised outer rim (*ḥajrah* or *ṭawq*) of 9 mm width. It is divided into angles marked clockwise from Zero to Three hundred and sixty degrees and every five degrees are marked in *abjad* notation. The interior of the mater houses a set of plates, with the rete on top. A notch in the plates fits into a small metallic protrusion (*mumsikah*) on the *ḥajrah*, thus preventing the plates from rotating freely. All the plates and rete have a hole at the centre through which passes the pin and it is secured in the front by a delicately designed horse-shaped wedge called *faras*.

1.4 The Rete

The rete of an astrolabe can be called the pièce de résistance and very aptly so in this particular astrolabe (Fig. 3). It displays the ecliptic ring and the positions of forty-six stars. A delicate floral design connects the star pointers (*shaẓiyyah*) to the main frame. The broad ring of the ecliptic is joined to the outer rim of the Tropic of Capricorn by the floral design and an east-west bar. A small metallic knob (*mudīr*) is inserted into the rete for rotating the rete. The circle of the celestial equator is not represented as done in some astrolabes. The ecliptic ring has the names of the zodiac signs, starting from the vernal equinox, and inscribed anti-clockwise. Each sign is subdivided into degrees, and groups of five degrees are numbered as five, ten, fifteen, twenty,

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[27] Gibbs and Saliba, *Planispheric Astrolabes from the National Museum of American History*, 62.

twenty-five, and thirty in abjad notation. The names of zodiac signs are written as *al-Ḥamal* (Aries), *al-Thawr* (Taurus), *al-Jawzā'* (Gemini), *al-Saraṭān* (Cancer), *al-Asad* (Leo), *al-Sunbulah* (Virgo), *al-Mīzān* (Libra), *al-'Aqrab* (Scorpio), *al-Qaws* (Sagittarius), *al-Jadī* (Capricornus), *al-Dalw* (Aquarius), and *al-Ḥūt* (Pisces). The names of forty-six stars engraved on the rete, their identification, and the modern names are shown in Table 1 below. The stars are arranged according to their increasing longitude, starting from the vernal equinox. In the last column, the modern names marked with an asterisk are derived from Arabic.

Fig. 3 Rete of the Astrolabe Made by Muḥammad Muqīm

Table 1: Stars on the Rete of the Astrolabe

S. No.	Star Names	Transliteration	Identification	Modern Names
1	القيطس الجنوبى	*Dhanab al-Qayṭus al-Janūbī*	β Ceti	Deneb Kaitos*
2	بطن الحوت	*Baṭn al-Ḥūt*	β Andromedae	Mirach*
3	ل المسلسلہ	*Rijl al-Musalsilah*	γ Andromedae	Almach*
4	فم طس	*Fam al-Qayṭus*	γ Ceti	
5	صدر لس	*Ṣadr al-Qayṭus*	π Ceti	
6	كف الجذما	*Kaff al-Jadhmā*	α Ceti	Menker*
7	رأس الغول	*Ra's al-Ghūl*	β Persei	Algol*
8	انى مسافت النہر	*Thānī Masāfat al-Nahr*	θ Eridani	Achernar*
9	دبران	*Dabarān*	α Tauri	Aldebaran*
10	العيوق	*Al- ʿAyyūq*	α Aurigae	Capella
11	يد الجوزا اليسرىٰ	*Yad al-Jawzā' al-Yusrā*	γ Orionis	Bellatrix
12	رجل الجوزا اليسرىٰ	*Rijl al-Jawzā' al-Yusrā*	β Orionis	Rigel*
13	رجل الجوزا اليمنىٰ	*Rijl al-Jawzā' al-Yumnā*	k Orionis	Saiph*
14	يد الجوزا اليمنىٰ	*Yad al-Jawzā' al-Yumnā*	α Orionis	Betelgeuse*
15	شعرىٰ يمانيہ	*Shiʿrā Yamāniyyah*	α Canis Majoris	Sirius
16	شعرىٰ شماليہ	*Shiʿrā Shamāliyyah*	α Canis Minoris	Procyon
17	ر الشجاع	*Minkhar al-Shujāʿ*	σ Hydrae	
18	راس الأسد	*Ra's al-Asad*	ε Leonis	
19	قلب الأسد	*Qalb al-Asad*	α Leonis	Regulus
20	ظهر الدب لاكبر	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris	Dubhe*
21	فرد الشجاع	*Fard al-Shujāʿ*	α Hydrae	Alphard*
22	ظهر سد	*Ẓahr al-Asad*	δ Leonis	Zosma
23	قاعدة لباطية	*Qāʿidat al-Bāṭīyah*	α Crateris	Alkes*
24	صرفة	*Ṣarfah*	β Leonis	Denebola*
25	جناح الغراب	*Janāḥ al Ghurāb*	γ Corvi	Gienah*
26	عناق	*ʿAnāq*	ξ Ursae Majoris	Mizar*

27	سماک العزل	*Simāk al-ʿAzal*	α Virginis	Spica
28	سماک الرامح	*Simāk al-Rāmiḥ*	α Bootis	Arcturus
29	عنق الحية	*ʿUnq al-Ḥayyah*	α Serpentis	Unuk*
30	كف شمالى	*Kiffah Shumalī*	β Librae	Zubeneschamali*
31	رأس الجاثى	*Ra's al-Jāthī*	α Herculis	Rasalgethi*
32	سر الواقع	*Nasr al-Wāqiʿ*	α Lyrae	Vega*
33	ركب الحواء اليسرى	*Rakba al-Ḥawwā' al-Yusrā*	ξ Ophiuchi	
34	رأس ا□واء	*Rā's al-Ḥawwā'*	α Ophiuchi	Rasalhague*
35	يد الحواء اليمنى ا□قدم	*Yad al-Ḥawwā' al-Yumnā al-Muqaddam*	δ Ophiuchi	Yad prior*
36	منقار الدجاجة	*Minqār al-Dajājah*	β Cygni	Albireo
37	سر الطائر	*Nasr al-Ṭā'ir*	α Aquilae	Altair*
38	ذنب الدجاجة	*Dhanab al-Dajājah*	α Cygni	Deneb*
39	ذنب الدلفين	*Dhanab al-Dulf īn*	ε Delphini	
40	فم الفرس	*Fam al-Faras*	ε Pegasi	Enif*
41	ذنب ا□دي	*Dhanab al-Jadī*	δ Capricorni	Deneb Algedi*
42	ساق ساكب الجنوبى	*Sāq Sākib al-Janūbī*	δ Aquarii	Skat*
43	ذنب القيطس شمالي	*Dhanab al-Qayṭus Shumālī*	ι Ceti	
44	نكب الفرس	*Mankib al-Faras*	β Pegasi	Scheat*
45	سرة الفرس	*Sirrat al-Faras*	δ Pegasi / α Andromedae	Alpheratz*
46	كف الخضيب	*Kaff al-Khaḍīb*	β Cassiopeiae	Caph*

1.5 The Plates

The five plates are well designed with clear inscriptions. Four of these are made for eight different latitudes and the fifth one is engraved with ecliptic coordinates on one side and with multiple horizons on the other side, as shown in table two.

Table 2: Plates of the Astrolabe

Plate	Latitude in degrees	Longest day in hours	Azimuth arcs	Unequal Hour lines	Dotted lines for equal hours

1a	20	13	Below the horizon 5°	yes	Drawn from both the eastern and western horizons
1b	36	14	Below the Horizon 5°	yes	Drawn from the western horizon
2a	25	13;25	Below the Horizon 5°	yes	Drawn from both the eastern and western horizons
2b	30	13;18	Below the Horizon 5°	yes	Drawn from the western horizon
3a	27	13;46	Below the Horizon 5°	yes	Drawn from both the eastern and western horizons
3b	32	14;8	Below the Horizon 5°	yes	Drawn from the western horizon
4a	34	14;16	Below the Horizon 5°	yes	Drawn from the western horizon
4b	42	15;2	Above the Horizon 5°	yes	Drawn from the western horizon

The first four plates display the local horizon. On these plates, two straight lines cross each other at the centre (North Pole) thus dividing the plate into four equal quadrants. The vertical line is the meridian (*khaṭṭ wasaṭ al-samāʾ*) that connects north (at the bottom of the plate) to the south (at the top of the plate) through the pole and the zenith. A part of this line from zenith to south is called *khaṭṭ niṣf al-nahār*. The horizontal line is called east-west line or level horizon (*ufuq al-istīwāʾ*). The true horizon is marked by an arc below the centre and is marked with "east" (*al-mashriq*) and "west" (*al-maghrib*). There are three concentric circles on the plates. The outermost circle at the periphery represents Tropic of Capricorn (*madār ra's al-jadī*), the next circle is the equator (*dā'irat al-iʿtidāl* and the innermost circle represents the Tropic of Cancer (*madār ra's al-saraṭān*).

Fig. 4 The Plate for Lahore at the Latitude of 32 degrees

1.5.1 The Almucantars

A basic requirement in observational astronomy is to find the altitude of an object. When we stand in the open, the imaginary circles of equal altitude are concentric between the horizon and the zenith. In case of the astrolabe these are represented by a set of eccentric circles (called almucantars from the Arabic word *al-muqanṭarah*) drawn between the horizon and the zenith. In the present astrolabe these circles are drawn for every degree from zero (the altitude of the horizon) to ninety degrees (zenith). Such astrolabes are classified as complete (Arabic: *tāmm*) while those having intervals of two or more degrees in circles are known by other designations. The accuracy of readings improves by the number of circles. In this astrolabe the almucantars are marked either by the odd numbers or the even numbers using the *abjad* notation. Every fifth circle has distinct dots on the circles to enhance legibility.

1.5.2 The Azimuth Arcs

The great vertical circles passing through the zenith and nadir intersect the almucantars at right angles. The lines for azimuth (from the Arabic word *al-samt*, "direction," plural *al-sumūt* transformed to azimuth) pass through the zenith. In this astrolabe the plates for seven latitudes have azimuth lines drawn below the horizon at intervals of 5°; as against this, on the plate for the latitude 42°, the azimuth arcs are drawn above the horizon at 5° intervals. These arcs are numbered from the west point (*nuqṭat al-maghrib*) on the horizon up the meridian from 0° to 90° at intervals of 5°. Similarly, azimuths are marked from the west point, in counter clockwise direction from 0° to 30° towards south. This pattern is repeated on the eastern side as well where the east point (*nuqṭat al mashriq*) is the starting point.

The space under the "horizon arc" (*taḥt al-arḍ*) is used for the label of the plate. The terrestrial latitude (*al-ʿarḍ*) is inscribed to the right of the meridian line and the duration of the longest day in hours (*al-sāʿāh*) is inscribed to the left the meridian line. Both these values are expressed in the *abjad* notation.

1.5.3 The Hour Lines

In the lower half of the plates are drawn lines for seasonal or unequal hours and equal hours. The seasonal hours are obtained by dividing separately the length of the day and the length of the night by twelve. Therefore they vary from the daytime to the night and from season to season. The equal hours are obtained by dividing the time from midnight to midnight, or from midday to midday, by twenty-four. Therefore the equal hours have always the same length. The seasonal hours are indicated by plain lines and are counted from the western horizon from one to twelve. The equal hours are indicated by dotted lines. On some plates, these are drawn from the western horizon and on some others, both from the eastern and western horizons.

1.5.4 The Plate of Ecliptic Coordinates

This plate carries the stereographic projections for the latitude which is the complement of the obliquity (ninety degrees minus the obliquity), roughly sixty-six; thirty degrees. On this plate the local horizon is the same as the ecliptic circle and the zenith coincides with the Pole. Here almucantars become latitude circles and the azimuths, the longitude circles. When the rete is placed upon this plate, the longitudes and latitudes of the star pointers can be measured and verified. Therefore, the plate is called *mīzān al-ʿankabūt* (i.e., "the balance of the rete"). It can also be used for converting ecliptic coordinates into equatorial coordinates and vice versa. [28]

On this plate, almucantars or latitude circles are drawn for each degree and alternate circles are numbered. The azimuth circles are drawn for every five degrees and numbered separately in each sign as five, ten, fifteen, twenty, twenty-five and thirty. Along the ecliptic circle, the names of the zodiac signs are inscribed in long strokes anti-clockwise. However, the name *mīzān al-ʿankabūt* is not engraved which is against the usual practice.

Fig. 5 The Plate of Ecliptic Coordinates

[28] See Morrison, *The Astrolabe*, 66.

1.5.5 The Plate of Horizons

On the reverse side of the fifth plate is engraved the plate of horizons (*ṣafīḥah āfāqiyyah*). It has three concentric circles of equator and two tropics. Two lines cross each other at the centre to divide the plate into four quadrants. In these four quadrants are drawn half horizons for each degree of latitude from four to sixty-five degrees. Declination scales are engraved along the diameters. The scales are numbered in units of five up to twenty-three; thirty which is the obliquity. Against the usual practice, the name of the plate *ṣafīḥah āfāqiyyah* is not written on this plate.

Fig. 6 The Plate of Horizons

Fig. 7 The Geographical Gazetteer

1.6 The Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer containing the names of one hundred and twenty localities (*al-bilād*) with their longitudes (*al-ṭūl*) and latitudes (*al-ʿarḍ*). In his gazetteers, Muqīm often varies the order of arranging the localities: sometimes he commences with the holy city of Makkah; sometimes he arranges the localities according to geographical regions like Andalus, Maghrib and so on; and sometimes he arranges them according to the climates of Greek antiquity.

In Ptolemaic geography, the inhabited portion of the world was divided into seven horizontal strips called climes or climates (*aqālīm*). The longest day in each climate is half an hour longer than in the previous climate. On the back of the present astrolabe, Muqīm engraved a table (see Table 3) showing the terrestrial latitudes at the beginning of each climate and the duration of the longest day at that latitude.

Muqīm also changes the physical arrangement of the data in the gazetteers. Generally, the data is engraved in small cells created by a series of concentric circles which are cut across by a number of diameters passing through the centre. In the present astrolabe, instead of straight diameters, he divides the concentric circles by lines which are all curved to one side, thus creating a spiral-like appearance.

There are four annuli in the present gazetteer. In each annulus, there are four rows or rings. The uppermost ring gives the title of the climate, the next lower ring gives the longitude of the city, and next lower ring gives name of the city and the last ring the latitude of that city. We may call this arrangement of data a set; where each set comprises of four rings. The outermost set has forty-seven names, the next set has thirty-five, then twenty-three and innermost set has fifteen names of the cities.

The heading on the outermost ring reads, "*az khaṭṭ-i istiwā', tā iqlīm-il awwal*" (from line of the equator up to the first climate). The last heading reads, "*khārij az iqlīm-i haftum*" (beyond the seventh climate.)"

S.No.	Place/City *al-Bilād*	*Long.* *al-Ṭūl*	*Lat.* *al-'Arḍ*	Transliteration	Modern Name
Annulus 1					
Az *Khaṭ-i Istiwā' tā Iqlīm Awwal* (From the Equator to the First Climate)					
1	ر ساحل اوقیانوس	11; 0	0; 0	Baḥr Sāḥil Awqiyānūs	Ocean Coast of Oceanus[29]
2	جزیره قنبله	21; 0	3; 0	Jazīrah Qanbalah	Madagascar
3	جمکوت	177; 0	5; 0	Jamkūt	Yamakoti[30]
4	شلا	180; 0	5; 0	Shilā	(in China)
5	کوه کو	54; 10	10; 0	Kōh-i kō	(in Africa)
6	عدن	76; 0	11; 0	'Adan	Aden, Yemen

[29] Oceanus (Greek *Okeanos*) is said to be the divine personification of the sea which encircles world.

[30] Sanskrit astronomical tradition envisages four notional cities on the terrestrial equator, which are separated from each other by 90°. Laṅkā is situated where the prime meridian which passes through Ujjain intersects the equator. Yamakoti is 90° east of Laṅkā (i.e., roughly at Long 165° E).

(The First Climate) *Iqlīm awwal*					
7	جبل	75; 0	13; 30	Jabal	Jabal Zuqar Island
8	دمار	77; 15	13; 30	Dammār	Dhamar, Yemen
9	لحه از بربر	10; 5	14; 0	Laḥah az bar bar [31]	Berbera, Africa
10	زبيد	74; 20	14; 10	Zabayd	Zabid, Yemen
11	صنعان در ملک یمن	77; 0	14; 30	Ṣanʿān dar Mulk-i Yemen	Sanʿā', Yemen
12	جند	75; 30	14; 30	Janad	Janad, Yemen
13	سومنات	107; 0	17; 0	Sōmnāt	Somnath, India
14	زيتون	114; 0	17; 15	Zaytūn	Hang Zhou, China
15	پنجا پور	105; 30	17; 20	Panjāpūr	Bijapur, India
16	برهانپور	108; 0	20; 30	Burhānpūr	Burhanpur, India
17	دولت آباد | 1	111; 0	20; 30	Daulatābād	Daulatabad, India
(Second Climate) (*Iqlīm-i Dūvum*)					
18	جده	76; 0	21; 0	Jeddah	Jeddah, Saudi Arabia
19	طايف	77; 30	21; 20	Ṭāyf [Ṭā'if]	Taif, Saudi Arabia
20	مكة مبارك	77; 10	21; 40	Makkah Mubārak	Mecca, Saudi Arabia
21	كنبيات	89; 20	22; 20	Kanbayāt	Cambay, India
22	-	75; 20	24; 20	Khayber	Khyber, Saudi Arabia
23	مدينه طيبة	75; 20	25; 0	Madīnah Ṭayyibah	Medina, Saudi Arabia
24	هرموز	92; 0	25; 0	Hurmūz	Hormuz, Iran
25	اجمير	110; 5	26; 0	Ajmīr	Ajmer, India
26	گوالير	114; 0	26; 29	Gwāliar	Gwalior, India
27	لكهنوتي	114; 18	26; 30	Lakhnōtī	Laknauti, India
28	قنوج	105; 50	26; 35	Qanūj	Kannauj, India
29	جونپور	119; 6	26; 36	Jaunpūr	Jaunpur, India
30	اکبر آباد دار [illegible]لافت	115; 0	26; 43	Akbarābād Dār al-Khilāfat	Agra (Akbarābād, the capital of the Caliphate), India
31	كو بامو	116; 38	26; 45	Kūbāmū	Gopamau, India

[31] E. S. Kennedy and M.H. Kennedy, "Al-Kāshī's Geographical Table," *Transactions of the American Philosophical Society* 77, no. 7 (1987): 41, carries a reproduction of a page from the India Office manuscript. Here appears the name of the city بربر از بلاد زنج , meaning "Berber from the land of Zanj" (Zanjistan became Zangibar and Zanzibar). It has been translated as Bajja of Berber on p. 7 (ibid).

32	مانکپور گڑھ	115; 10	26; 49	Mānikpūr gaṟh	Manikpur, India
33	اودھ	118; 6	27; 22	Awadh	Awadh, India
34	بداؤن	115; 14	27; 40	Badā'ūn	Badaun, India
Third Climate (*Iqlīm-i Sivum*)					
35	بکر	105; 0	27; 40	Bakr	
36	کول کنده	114; 20	28; 4	Kōlkandah	Golconda (Hyderabad), India
37	کول لالی	114; 19	28; 4	Kōl [wa] Jalālī	Aligarh and Jalali, India
38	فیروز آباد	87; 30	28; 10	Fīrūzābād	Firuzabad, India
39	سلطان کوت	115; 0	28; 30	Sulṭānkōṭ	Sultankot, India
40	دهلی دارالملک الهند	103; 35	28; 39	Dihlī dār al-Mulk al-Hind	Delhi (the capital of India)
41	برن	114; 0	28; 48	Baran	Bulandshahar, India
42	پانی پت	113;20	28; 52	Panīpat	Panipat, India
43	شیراز	88; 0	29; 36	Shīrāz	Shiraz, Iran
44	ملتان	107; 35	29; 40	Multān	Multan, Pakistan
45	انسی	112; 25	29; 45	Hānsī	Hansi, India
46	بصره	84; 0	30; 0	Baṣrah	Basra, Iraq
47	کرمان	91; 30	30; 5	Kirmān	Kerman, Iran
Annulus 2 *Tatimmah-i Iqlīm-i Sivum* (Continuation of the Third Climate)					
48	سر	112; 38	30; 10	Tānīsar	Thanesar, India
49	کندریه	61; 54	30; 18	Iskandaryah	Alexandria, Egypt
50	مصر	63; 20	30; 20	Miṣr	Cairo, Egypt
51	سنام	112; 25	30; 30	Sunām	Sunam, India
52	پرشور	85; 55	31; 0	Parshōr	Peshawar, Pakistan
53	کوفه	79; 30	31; 30	Kūfah	Kufa, Iraq
54	بیت المقدس	66; 30	31; 50	Bayt al-Maqdis	Jerusalem, Israel
55	لاهور دارالسلطنت	109; 20	31; 50	Lāhōr Dār al-Salṭanat	Lahore (the capital of the Sultanate), Pakistan
56	یزد	89; 0	32; 0	Yazd	Yazd, Iran
57	اصفهان	87; 40	32; 25	Iṣfahān	Isfahan, Iran
58	فرمل	104; 35	32; 55	Farmal	
59	قندها ر	107; 40	33; 0	Qandahār	Qandahar, Afghanistan
60	کوٹ	109; 0	33; 0	Siyālkōṭ	Sialkot, Pakistan

61	مداین	72; 0	33; 15	Madāyin	Madain, Iraq
62	دمشق	70; 0	33; 15	Dimashq	Damascus, Syria
63	میمند	101; 55	33; 20	Maymand	Meymand, Iran
64	بغداد	82; 0	33; 25	Baghdād	Baghdad, Iraq
Iqlim-i Chahārum (Fourth Climate)					
65	طرابلس	69; 40	34; 0	Ṭarābulus	Tripoli, Libya
66	عانه	76; 0	34; 0	ʿĀnah	Anah, Iraq
67	کا شان	86; 0	34; 0	Kāshān	Kashan, Iran
68	موصل	77; 0	34; 30	Mawṣil	Mosul, Iraq
69	تون	92; 30	34; 30	Tūn	Tun, Iran
70	ہرات	94; 30	34; 30	Hirāt	Herat, Afghanistan
71	کابل	104; 40	34; 30	Kābul	Kabul, Afghanistan
72	قم	85; 40	34; 45	Qum	Qom, Iran
73	ری	86; 20	35; 0	Rayy	Rayy, Iran
74	ساوه	85; 0	35; 0	Sāwah	Saveh, Iran
75	میر	108; 0	35; 0	Kashmīr	Srinagar, India
76	ہمدان	83; 0	35; 10	Hamadān	Hamadan,Iran
77	حلب	72; 10	35; 50	Ḥalab	Aleppo, Syria
78	مشهد	92; 30	36; 0	Mashhad	Mashhad, Iran
79	سہرورد	88; 20	36; 0	Suhravard	Suhraward, Iran
80	سبزوار	91; 30	36; 5	Sabzvār	Sabzevar, Iran
81	بسطام	89; 30	36; 10	Basṭām	Bastam, Iran
82	بلخ	101; 0	36; 11	Balkh	Balkh, Afghanistan
Annulus 3					
Tatimmah-i Iqlīm-i Chahārum (Continuation of the Fourth Climate)					
83	طالقان	85; 45	36; 10	Ṭāliqān	Taloqan, Afghanistan
84	البحر	84; 30	36; 45	Al-bahar	Al-bahar ?
85	استراباد	89; 35	36; 50	Astarābād	Gorgan, Iran
86	قزوین	85; 0	35; 55	Qazwīn	Qazvin, Iran
87	بدخشان	84; 24	37; 10	Badakhshān	Faizabad, Afghanistan
88	مراغه	82; 0	37; 20	Marāghah	Maragha, Iran
89	سرخس	94; 30	37; 30	Sarakhs	Sarakhs, Iran
90	مرو	97; 0	37; 40	Marw	Merv or Mary, Turkmenistan
91	تبر	82; 0	38; 0	Tabrīz	Tabriz, Iran
92	اردبیل	80; 30	38; 0	Ardabīl	Ardabil, Iran

93	نوشہر	78; 20	38; 10	Naushahr	Noshahr, Iran
94	نخجوان	81; 15	38; 40	Nakhijvān	Nakhichevan, Azerbaijan
Iqlīm-i Panjum (Fifth Climate)					
95	باکویہ	84;30	39; 30	Bākūyah	Bakuyah
96	قند	99; 16	39; 37	Samarqand	Samarqand, Uzbekistan
97	بخارا	97; 30	39; 50	Bukhārā	Bukhara, Uzbekistan
98	تبت	110; 0	40; 0	Tibbat	Tibet (Lhasa)
99	بردعه	83; 0	40; 30	Bardaʿah	Barda, Azerbaijan
100	ي	84; 30	40; 50	Shamākhī	Shamakhi, Azerbaijan
101	قونیہ	66; 30	41; 0	Qūniyah	Konya, Turkey
102	خجند	105; 35	41; 55	Khujand	Leninabad, Russia
103	ختن	107; 0	42; 0	Khutan	Khotan, China
104	كا شا ن	81; 35	42; 0	Kāshān	Kashan, China
105	فرغانہ	102; 0	42; 20	Farghānah	Farghana, Uzbekistan
Annulus 4					
Iqlīm-i Shashum (Sixth Climate)					
106	كاشغر	106; 30	44; 0	Kāshghar	Kashgar, China
107	بندقیہ	92; 0	44; 0	Bandqiyah	
108	شلخ	100; 30	44; 0	Shalkh	Chulak-kurgan, Kazakhstan
109	طراز	99; 50	44; 31	Ṭarāz	Dzhambul, Kazakhstan
110	بالغ بیش	111; 0	45; 50	Bāligh baish	Pochongtse, China
111	قراقوروم	115; 0	46; 0	Qarāqūrūm	Karakoram
112	خان بالغ	124; 0	46; 0	Khān Bāligh	Beijing, China
113	ہرقلہ	67; 20	46; 30	Harqlah	Eregli, Turkey
Iqlīm-i Haftum (Seventh Climate)					
114	ارق	100; 0	48; 0	Araq	Araq
115	بلغار	90; 0	49; 30	Bulghār	(Bulgars)
116	اقچا كرمان	62; 0	50; 0	Aqchā kirmān	Belgorad-Dnistrowskyj, Ukraine
117	قرقر	65; 30	50; 0	Qir qir	(in Crimea)

Khārij az Iqlīm-i haftum (Beyond the Seventh Climate)					
118	ماری کرمان	65; 45	50; 40	Mārī Kirmān	Mari Kirman
119	جزایر رود جرد	68; 50	62; 0	Jazāyir rūdjard	
120	صوداق	66; 5	51; 0	Ṣudāq	Sudak, Crimea

1.7 The Back of the Astrolabe

A north-south vertical line and an east-west horizontal line divides the back of the astrolabe (*ẓahr al-asṭurlāb*) into four quadrants (*rub'ṣ*). The outer rim of the two upper quadrants carries a degree scale for measuring the altitude of heavenly bodies. The scale is divided in single degrees and groups of five degrees are labelled in *abjad*. The angles of altitude are numbered from the horizon in the east and west proceeding up to the south point at the top.

Fig. 8 The Back of the Astrolabe

1.7.1 The Upper Left Quadrant

It is also termed as the south-eastern quadrant (*al-rubʿ al-sharqī al-janūbī*). It carries the sine-cosine graph with sixty horizontal and sixty vertical parallel lines. Every fifth line highlighted with dots. With the help of this sine-cosine graph, the angles of altitude measured by the alidade can be directly converted to the corresponding sines or cosines.

1.7.2 The Upper Right Quadrant

It is also called the south-western quadrant (*al-rubʿ al-gharbī al-janub*. It has sixty concentric quarter-circles of equal intervals. Every tenth circle is prominently marked with a distinct dotted line. The names of six zodiac signs are written along the horizontal radius of the quadrant and the other six names are written along the vertical radius. On the horizontal axis are written the names of Capricorn, Aquarius, Pisces, Aries, Taurus and Gemini, from the periphery up to the centre (i.e., from winter solstice to summer solstice). Along the vertical axis are inscribed the names of Cancer, Leo, Virgo, Libra, Scorpio and Sagittarius, starting from the centre (i.e., from summer solstice to winter solstice). Each zodiac sign is divided into ten parts of three degrees each, as represented by the quarter-circles. Every alternate division is numbered in *abjad* as six, twelve, eighteen, twenty-four and thirty.

In this quadrant, two sigmoid curves for the noon altitude of the sun are drawn for the latitudes of 27° and 32°. The upper curve has the label "the line of midday altitude at 27° latitude" (*khaṭṭ-i nisf al-nahār al-ʿarḍ*. A similar label is on the lower curve for 32° latitude. The two prominent cities on these latitudes are Agra and Lahore respectively, the imperial seats of Mughals. This arrangement of circles and curves enables the user to find the solar altitude at the meridian passage of the sun throughout the year. The conversion of solar altitude to the time of the day was equally simple and straightforward.

1.7.3 The Shadow Squares

In the lower half are drawn the shadow squares. The south-north vertical line divides these into two parts. On the two lower corners there is a label each reading *ẓill-i sullam* (the scale of shadows). The umbra recta is the direct shadow of a vertical gnomon on the horizontal plane and the umbra versa is the reverse shadow of a horizontal gnomon on the vertical plane. The right half of the square is for a gnomon of seven feet. Therefore the horizontal and vertical scales on this side are divided in to seven parts each which are reckoned in "feet" (Arabic *qadam*; pl. *aqdām*). The horizontal scale is marked 1, 2, 3, 4, 5, 6 and 7 (from centre to right). The vertical scale has markings 1, 2, 3, 4, 5, 6 and 7 (from top to bottom). The horizontal scale is labelled as *ẓill-i aqdām mustavī* (i.e., umbra recta in feet). The words *ẓill-i aqdām maʿkūs* (i.e., umbra versa in feet), are inscribed along the vertical scale.

Likewise the square on the left is designed for a gnomon of twelve digits or "fingers" (*iṣbaʿ*; pl. *aṣābiʿ*). The horizontal scale of this rectangle is labelled as *ẓill-i aṣābiʿ mustavī* (سابع مستوی) and vertical scale is labelled as *ẓill-i aṣābiʿ maʿkūs* (ظل اصابع معکوس).[32]

1.7.4 The Table of Climates inside the Shadow Squares

Inside the shadow squares, immediately below the horizontal diameter, is a table consisting of three columns and seven rows. Its heading is *mābādī ʿaqālīm-i sabʿa* (beginning of seven climates). The word *intihāh* (last limit) is inscribed just below the table. This indicates the zone beyond (i.e., north of) seventh clime.

Table 3. Beginnings of the Seven Climates

Climate	Latitude	Hours
First	12;48	12;45
Second	20;31	13;15
Third	27;34	13;45
Fourth	38;43	14;15
Fifth	39;1	14;45
Sixth	43;30	15;15
Seventh	47;38	15;45
انتہا *(intihā)* "last limit"	50;31	16;15

1.7.5 Cotangent Scales

On the rim of the lower half are two cotangent scales, on the left in digits and on the right in feet, corresponding to the shadow scales. The scales have numbers written in *abjad* from the centre to either side as 5, 10, 15, and so on up to 90.

1.7.6 Astrological Tables

Inside the cotangent scales and again inside the shadow squares, there are several concentric semi-circular rows in which various tables of astrological interest are engraved upside down. Inside the cotangent scales are two astrological tables engraved in five concentric semi-circular rows. The first

[32] The shadow square has measurements in "feet" (*aqdām*) and "fingers" (*aṣābiʿ*) The genesis of these terms is described by Gibbs and Saliba see Gibbs and Saliba, *Planispheric Astrolabes from the National Museum of American History*, 226. The Greeks measured the height of a person in relation to the length of his foot at 7:1. This tradition of dividing shadows in 7 parts was followed by Muslims as well. In Babylon it was found that at night 1/12th of a degree in sky is obscured by a finger held at arm's length. Thus the shadow was also divided in terms of 12 fingers.

three rows constitute the table of "limits" or "terms" (*ḥudūd*). Here each sign of the zodiac is divided in five parts and each part is assigned to a planet other than the sun and the moon, but the planets have varying strengths. In the outermost row are the names of the planets, represented by the last letter of their Arabic names, in the middle row the names of the signs and in the third row the numerical strengths of the planets in *abjad* notation.

The second row, together with the fourth and fifth rows, forms the table of decans (*wujūh*) and their regents. Here each sign is divided into three decans of 10° each, and assigned a regent. The decans are also known as "faces" or "aspects."

Inside the shadow squares, there are once again five semi-circular rows. In the outermost row are the names of the 12 signs of the zodiac; in the next row are the names of the 28 corresponding lunar mansions.

The remaining rows contain "triplicities" or "trigons" (*muthallath*, pl. *muthallathāt*). In this arrangement, the signs are divided into 4 groups so that in each group the signs are separated by 120°. These four groups carry the labels "fiery" (*nārī*), "earthy" (*turābī*), "airy" (*havā'ī*) and "watery" (*māhī*) respectively.[33]

1.8 The Alidade.

On the back of the astrolabe is the alidade. It is a 38 mm thick and 232 mm long metallic strip in the shape of a trapezoid. The shorter side is 190 mm and it has a width of 20 mm. The two vertical strips (used for observation of celestial objects) are 190 mm apart. These are 24 mm high and 18 mm in width with a thickness of 3 mm. Both the sighting vanes have two holes each, smaller one for sighting objects during daytime and bigger hole for stars at night. The alidades of the Lahore astrolabes usually carry scales corresponding to the divisions on the two upper quadrants on the back. But the present is alidade is completely blank without any scales. Therefore, it may not be original but a replacement.

1.9 The Minor Components

The pin (*quṭb*) and the wedge (*faras*) of the astrolabe are mechanically functional and hold the plates and rete together with the mater. On the face of astrolabe is a horse-shaped wedge (*faras*) and a metallic ring (*fals*). The wedge (47 mm long) is very delicately made in its full detail. The mane of the horse,

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[33] For details about these tables, see George Rusby Kaye, *The Astronomical Observatories of Jai Singh* (New Delhi: Archaeological Survey of India, 1982), 120–26. M. P. Khareghat, *Astrolabes*, ed. Dinshaw D. Kapadia (Bombay: Shahnamah Press, 1950), 11–23.

the head and the eyes are its main striking features. All the plates and rete are attached to the mater by jib and cotter arrangement. The stove-head bolt (*quṭb*) fits into 8 mm diameter hole (*mahan*).

Fig. 9 The Name of the Maker and the Date of Manufacture on the Astrolabe

1.10 The Name of the Maker and the Date of Manufacture.

Along the inner boundary of the semi-circular table there is an inscription which reads:

> *ṣanʿat-i aḍʿaf al-ʿibād Muḥammad Muqīm ibn ʿĪsā ibn Allāh Dād asṭurlābī Humāyūnī Lāhōrī* (Made by the weakest of the creatures [of Allah] Muḥammad Muqīm son of ʿĪsā son of Allāh Dād of Lahore, the astrolabe maker of [the Emperor] Humāyūn).

The time of production of this astrolabe is mentioned in three different eras. Under the name of the maker is written "in 1047 year Hijrī." The other two dates i.e., "in 1007 year Yazdegirdī" and "in 1949 year Rūmī" are written on either side of shadow square. The Yazdegirdī year 1007 is from October 18, 1637 to October 17, 1638. The Rūmī (i.e., Syro-Macedonian era) year 1949 is from October 11, 1637 to 10 October 1638. The Hijrī year 1047 is from May 27, 1637 to May 14, 1638 AD. Therefore, the date of this astrolabe can be placed between end of 1637 and early 1638.

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