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THE GURMUKHI ASTROLABE OF THE MAHARAJA OF PATIALA

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Even though the telescope was widely in use in India, the production of naked eye observational instruments continued throughout the nineteenth century. In Punjab, in particular, several instrument makers produced astrolabes, celestial globes and other instruments of observation, some inscribed in Sanskrit, some in Persian and yet some others in English. A new feature was the production of instruments with legends in Punjabi language and Gurmukhi script. Three such instruments are known so far. One of these is a splendid astrolabe produced for the Maharaja of Patiala in 1850. This paper offers a full technical description of this Gurmukhi astrolabe and discusses the geographical and astrological data engraved on it. Attention is drawn to the similarities and differences between this astrolabe and the other astrolabes produced in India.

Key words: Astrolabe, Astrological tables, Bhālūmal, Geographical gazetteer, Gurmukhi script, *Kursī*, Maharaja of Patiala, Malayendu Sūri, Rahīm Bakhsh, Rete, Rishīkes, Shadow squares, Star pointers, Zodiac signs

INTRODUCTION

For the historian of science and technology in India, the nineteenth century is an interesting period when traditional sciences and technologies continued to exist side by side with modern western science and technology before ultimately giving way to the latter. In the field of astronomical instrumentation, although the telescope was in use throughout the sub-continent and although modern astronomical observatories were set up at Madras in 1786 and at Trivandrum in 1837,[1] production and use of naked eye observational instruments continued throughout the nineteenth century as an adjunct to the pursuit of astronomy according to Sanskrit and Islamic traditions.[2]

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0.1 Astronomical Instrumentation in Punjab

Especially in Punjab, there seems to have existed a vibrant tradition of producing astronomical instruments pertaining to the Sanskrit and Indo-Persian or Islamic traditions. A notable figure in this connection is Lālā Bhālūmal Lāhūrī (*fl.* 1839-1850),[3] a scholarly instrument maker, well versed in Persian and Sanskrit and expert in both the traditions of instrument making, who produced astrolabes, celestial globes, horary quadrants, *Dhruvabhrama-yantras* and others, some inscribed in Arabic-Persian and others in Sanskrit. He is perhaps the last representative of both the Islamic and Hindu traditions of scientific instrumentation. He was patronized by the Maharaja of Kapurthala, for whom he made a celestial globe in 1842 and received 490 *ashrafī* coins as reward.[4] His pupil Ghulām Qādir Kapūrthalī is known by an astrolabe produced in 1861.[5] A contemporary and perhaps an associate of Bhālūmal was Joshi Dhurm Chund (*fl.* 1854-1873) who produced several interesting instruments, some inscribed in Sanskrit, some in Persian and yet some others in English.[6]

0.2 Gurmukhi Instruments

A new feature of astronomical instrumentation in Punjab in the nineteenth century is the production of instruments with legends in Punjabi language and Gurmukhi script. Three instruments are known so far, viz. a splendid astrolabe, a rare double quadrant, and a huge Zarqālī universal astrolabe. As will be shown below, the astrolabe was made in 1850 for the Maharaja of Patiala. I have briefly reported about this astrolabe in an earlier publication[7] and a full-length study is offered in the following pages. The double quadrant and the Zarqālī astrolabe do not contain any information about the maker or about the time of production, but it is quite likely that these were also made about the same time at the court of Patiala. I had the opportunity to personally examine the astrolabe and the quadrant; they appear to have been made by the same instrument maker. The inscription on the double quadrant designates it as a *Cāpa-yantra*. The *Cāpa-yantra* was first described by Brahmagupta in the seventh century and subsequently by many other writers, but this is the only extant specimen known so far.[8] The Zarqālī astrolabe, with a diameter of about one meter, is one of the largest astrolabes in the world. It is also one of the few Zarqālī astrolabes that are extant. On this astrolabe, most of the inscriptions, including the arguments on the various scales, are engraved in Arabic and Gurmukhi scripts.[9]

The astrolabe and the double quadrant were in a private collection in Germany; after the owner's death a few years ago, they were inherited by his heirs. The Zarqālī astrolabe came up for auction at Christie's of London in 1992[10] and was acquired by a private collector in Milan. It has changed hands recently and moved to a private collection in London.

1.0 The Gurmukhi Astrolabe

The inscription[11] engraved on the back of the astrolabe states that the astrolabe was produced by the order of Maharaja Narinder Singh of Patiala (r. 1845-1862) on a date corresponding to 14 March 1850 and that the person who got it made (*banāūṇevāle*) is Jotishī Śrī Rishīkes and the artisan (*kārīgar*) who made it is Rahīm Bakhsh. It means that the astrologer Rishīkes designed the astrolabe by preparing the technical drawings for it and that the artisan Rahīm Bakhsh fabricated the astrolabe according to the technical drawings and engraved the legends and numerals. In the geographical tables engraved on the astrolabe, the latitudes of all localities are given in degrees and minutes, but the latitude of Kumaon, or rather the city of Almora, is given in degrees, minutes and seconds (see Table 3, no. 38). Such very fine measurement for this one locality would suggest that the astrologer Rishīkes who designed this astrolabe may have hailed from Almora. Probably he was the court astrologer of the Maharaja of Patiala. That he was primarily an astrologer is also evident from the abundance of astrological data on this astrolabe (see sections 1.4.1 and 1.4.2 below).[12]

The inscription is in Punjabi language and Gurmukhi script. All the legends and numerals are in Gurmukhi.[13] These are deeply engraved and filled with black enamel. The brass astrolabe is in an excellent state of preservation and looks gilded. It has a diameter of 195 mm and a height of 247 mm and is 12 mm thick. The main body or mater of the astrolabe[14] is surmounted by an elaborately carved and reticulated bracket or *kursī* with symmetrical floral pattern in high relief on both sides (Fig. 1). Though the pattern is identical in the front and on the back, the elevations are more pronounced in the front whereas on the back the pattern is softer (compare Figs. 1 and 5). The profiles of the *kursī* on the left and right are formed of tiered lobes. To the tip of the *kursī* is affixed a simple and small shackle, through which passes a large ring with a ribbed outer surface. These two enable the astrolabe to be suspended in a vertical plane and to be rotated

Fig. 1. The Gurmukhi Astrolabe, the front. The alidade is wrongly attached to the front. It should have been fixed on the back

around the vertical axis. The upraised rim of the mater is graduated in 60 divisions and numbered in Gurmukhi numerals serially from 1 to 60, running clockwise. On the inner side of the rim, each division is further subdivided into 6 parts, i.e. into single degrees of arc. The mater accommodates six plates and a rete, all having a diameter of 171 mm.

1.1 The Rete

The rete is delicately crafted (Fig. 2), without overloading it with too many star pointers. The three rings containing the circles of the Tropic of Capricorn, the equator and the ecliptic are held together by the east-west

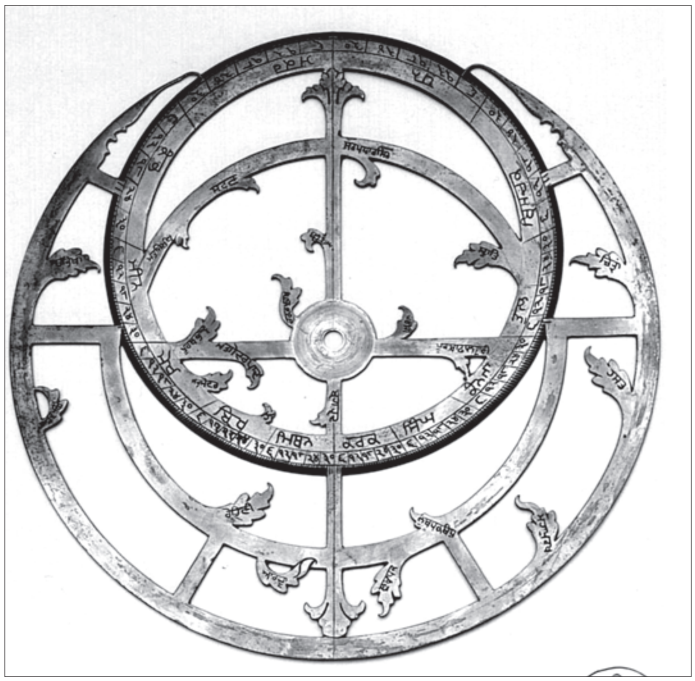

Fig. 2. The Rete with named Star Pointers

equinoctial bar with two counter changes and the south-north solsticial bar without any counter change. The ecliptic is divided into 12 signs and labelled as follows: *Mekha* (Sanskrit: *Meṣa*), *Brikha* (*Vṛṣa*), *Mithana* (*Mithuna*), *Karaka* (*Karka*), *Siṃgha* (*Siṃha*), *Kaṃnyā* (*Kanyā*), *Tula* (*Tulā*), *Brisacaka* (*Vṛścika*), *Dhana* (*Dhanuḥ*), *Makara* (*Makara*), *Kuṃbha* (*Kumbha*), *Mīna* (*Mīna*). Each sign is further subdivided into groups of 6º and labelled as 6, 12, 18, 24, 30 in counter-clockwise direction. These are further divided into single degrees on the sloped edge of the ecliptic ring, but not labelled.

There are 10 leaf-shaped star pointers outside, i.e., to the south of the ecliptic, and 12 inside, i.e. to the north of the ecliptic. These are listed below in the order of increasing right ascension (Table 1).

Table 1: Stars on the Rete

S. No.	Star Name	Star Name in Sanskrit	Identification	Common Name
1	*samudrapachī*	*samudra-pakṣī*	β Cet	Diphda
2	*matsodara*	*matsyodara*	β And	Mirach
3	*matsodarapāda*	*matsyodara-pāda*	γ And	Almach
4	*pra*	*preta-śira*	β Per	Algol
5	*rohiṇī*	*rohiṇī*	α Tau	Aldebaran
6	*brahāhrada*	*brahma-hṛdaya*	α Aur	Capella
7	*āradrā*	*ārdrā*	α Ori	Betelgeuse
8	*lubadhaka*	*lubdhaka*	α CMa	Sirius
9	*lubadhakabaṃdhu*	*lubdhaka-bandhu*	α CMi	Procyon
10	*mahāpurakha*	*mahāpuruṣa*	α Hyd	Alphard
11	*pūrabā phālagunī*	*pūrva-phālgunī*	δ Leo	Zosma
12	*hasata*	*hasta*	δ Cor	Algorab
13	*citrā*	*citrā*	α Vir	Spica
14	*marīcī*	*marīci*	η UMa	Alkaid
15	*svāti*	*svāti*	α Boo	Arcturus
16	*sarapadhārasira*	*sarpadhārī-śira*	α Oph	Rasalhague
17	*abhijit*	*abhijit*	α Lyr	Vega
18	*sravana*	*śravaṇa*	α Aql	Altair
19	*rukurapuhara*	*kukkuṭa-puccha*	α Cyg	Deneb
20	*matasimukha*	*aśvamukha*	ε Peg	Enif
21	*satabhikhā*	*śatabhiṣā*	λ Aqr	
22	*purababhādra*	*pūrva-bhādrapada*	β Peg	Scheat

1.2 The Plates

There are six plates in this astrolabe, each with a small triangular projection at the bottom, which fits into a triangular slot in the rim of the mater (Fig. 3). These six plates serve 11 different cities situated on latitudes ranging from 18º to 52º. One plate face, which we designate as 6b, is devoted to astrological data and will be discussed in section 1.4.2 below. Interestingly, one of the plates is devoted to two capitals. This plate carries on one side projections for the latitude of 30º on which lies Patiala, the capital city of the Maharaja who commissioned this astrolabe. The reverse side of the plate is calibrated for the latitude of 52º on which is situated the City of London (*sahar nandan*), the powerful capital of the British Colonial Power with which the Maharaja of Patiala entered into a treaty of alliance against Maharaja Ranjit Singh of Lahore in 1808. This is reminiscent of the practice in the Lahore astrolabes where one plate is usually devoted to the two imperial cities Agra and Lahore.

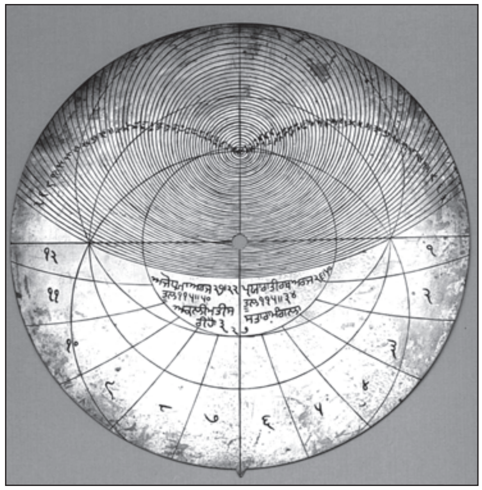

Fig. 3. Plate 3b, calibrated for the latitude of 27º

All the plates (except 6b) carry stereographic projections of the Tropic of Capricorn, the Equator and the Tropic of Cancer as three concentric circles. There is also the projection of the ecliptic circle, which is usually not found on astrolabe plates. The east-west line and north-south line are represented by horizontal and vertical diameters. On this grid is drawn the local horizon for the latitude concerned. Above the local horizon can be seen a series of equal altitude circles or almucantars. These are drawn at intervals of one and half degrees and the alternate lines are labelled as 3, 6, 9 … 90, both to the east and west of the meridian. This is also unusual, because normally the almucantars have intervals of integer number of degrees. In the lower half of the plates, there are unequal hour lines, which are numbered from the western horizon. On 1a and 1b there are also equal hour lines drawn from the western horizon. All plates carry a complete azimuth circle at 0º. Other azimuth lines vary from plate to plate. On 1a, azimuths are drawn for every 6º above the horizon and numbered along the local horizon only to the left of the meridian; on 1b, 4a, 4b and 6a, there are azimuth lines for every 6º above the horizon, but only partially.

Indo-Persian astrolabes, and also a few Sanskrit astrolabes, contain a special plate, one side of which carries projections for the latitude of 66º. This is roughly equal to 90º minus the obliquity of the ecliptic. This projection is designated as *Ṣafīḥa al-mīzān al-ʿankabūt,* “the plate for measures on the

^{c}*ankabūt* or rete”. The other side of the plate carries the projections of multiple horizons and is entitled *Ṣafīḥa al-afāqiyah,* “the plate of horizons”.[15] The present astrolabe does not contain such a plate.

On all the plates, in the space between the local horizon and the Tropic of Cancer, much data is engraved which is not met with in other Indo-Persian or Sanskrit astrolabes. This data includes the name of the city for which the particular side of the plate is calibrated, its latitude (*araj,* from Arabic *arḍ*) and longitude (*tūl,* from Arabic *ṭūl*), the climate (*aklīm,* from the Arabic *iqlīm*) and the name of the presiding planet (*satārā*) of this climate.[16] The duration of the longest day at this latitude is not mentioned here, as is generally done on all Indo-Persian astrolabes and also on some Sanskrit astrolabes. As in all medieval astrolabes, the longitudes engraved here are counted from the Fortunate Isles, which are situated to the west of the Straits of Gibraltar in the Atlantic Ocean. Ptolemy used these islands as the reference for measuring the terrestrial longitudes in his *Geography*, and Islamic astronomy adopted the same convention, calling the islands *al-Jazā'ir al-Khalidāt.*[17] These longitudes were in use until 1884 when an international convention adopted the meridian of the Greenwich Observatory as 0º longitude. Since the present astrolabe was produced in 1850, it still uses the longitudes as measured from the Fortunate Isles. However, for the cities of London and Kolkata, it provides just the latitudes and not the longitudes.

More important is that on the plates of this astrolabe are mentioned the names of other cities which lie close to the latitude of the principal city and their latitudes and longitudes. The purpose of this enumeration is that if a city lies close to the latitude for which the plate is calibrated, then the same plate can be used in that city also. This practice does not obtain in the Indo-Persian astrolabes produced in the Lahore family or in Sanskrit astrolabes, but is described in the *Sīrat-i Fīrūz Shāhī*, composed in 1370 at the court of Fīrūz Shāh Tughulq.[18] This practice is met with also in a bilingual astrolabe produced at the court of Jahāngīr in 1616.[19] These three cases attest to the existence in India of a tradition of Indo-Persian astrolabes which is different from that of the Lahore family.

The latitude for which a particular side of a plate is calibrated is mentioned at the junction of the meridian and the tropic of Cancer. The legends on the plates are reproduced below in serial order and translated into English.

Plate 1a for the Latitude of 30º

paṭīālā araj 30|13	*kurukhetra araj 30||10||*
tūl 111|30	*tūl 112|*
yah aklīm 3	*ihā kā satārā*
tīsarī hai	*maṃgal*
30	
Patiala, Latitude 30º 13′	Kurukshetra, Latitude 30º 10′
Longitude 111º 30′	Longitude 112º
This climate	The planet here [is]
is the third 3	Mars

Plate 1b for the Latitude of 52º

sahar naṃdan araj	*aklīm cauthī 4*
	satārā sūraj
52	
City of London, Latitude	Climate fourth 4
52	Planet the Sun

Plate 2a for the Latitude of 24º

dūsarī duvārakā araj 24|45	*madīnā araj 25||0*
tūl 59	*tūl 75||*
yah aklīm	*ihā kā satārā*
dūsarī hai ||	*brahaspat hai ||*
24	
The second Dwaraka,[20] Lat 24º 45′	Madīnā, Latitude 25º 0′
Longitude 59º	Longitude 75º
This climate	The planet here is
is the second 2.	Jupiter.

Plate 2b for the Latitude of 32º

sahar lāhaur araj 31	*sahar kaṃdhār araj*
||50|| tūl 109|20	*33|0| tūl 107140* (!)
aklīm tī-	*satārā maṃgal*
sarī 32	
City of Lahore, Latitude 31º 50′	City of Qandahar, Latitude 33º 0′
Longitude 109º 20′	Longitude 107º 140′ [21]
Climate [is] the third	Planet Mars

Plate 3a for the Latitude of 35º

kāsmīr araj 35|1	*kābal araj 34|30*
tūl 108 yih a-	*tūl 104||40||*
klīm tīsarī	*satārā maṃgal*
35	
Kashmir, Latitude 35º 1′	Kabul, Latitude 34º 30′
Longitude 108º	Longitude 104º 40′
This climate [is] the third.	Planet Mars.

Plate 3b for the Latitude of 27º

ajodhyā araj 27|22	*prayāg tīrath araj 26|50*
tūl 115||50	*tūl 115|34*
aklīm tīsa-	*satārā maṃgalā*
rī hai 3	
27	
Ayodhyā	Prayag (the place of pilgrimage)
Latitude 27º 22′	Latitude 26º 50′
Longitude 115º 50′	Longitude 115º 34′
The climate is the third *3*.	Planet Mars

Plate 4a for the Latitude of 31º

<table>
<tr><td>misar araj 30||30</td><td>multān araj 29|40</td></tr>
<tr><td>tūl 63||1</td><td>tūl 107||35</td></tr>
<tr><td>aklīm tīsa-</td><td>satārā || maṃgal</td></tr>
<tr><td>rī 3</td><td></td></tr>
<tr><td>31</td><td></td></tr>
<tr><td>Egypt, Latitude 30º 30′</td><td>Multān, Latitude 29º 40′</td></tr>
<tr><td>Longitude 63º 1′</td><td>Longitude 107º 35′</td></tr>
<tr><td>Climate</td><td>Planet Mars</td></tr>
<tr><td>third 3.</td><td></td></tr>
</table>

Plate 4b for the Latitude of 21º

<table>
<tr><td>burhānpur araj 21||21</td><td>devagiri araj 20||34</td></tr>
<tr><td>tūl 113||0</td><td>tūl 111||0</td></tr>
<tr><td>sūrat ba[m?]bai 20|0| tūl</td><td>makkā araj 21||40</td></tr>
<tr><td>50</td><td>tūl 76||10</td></tr>
<tr><td>kalakatā araj | 22||</td><td>duārak araj 22|31</td></tr>
<tr><td>aklīm 3 satrā-</td><td>tūl 56</td></tr>
<tr><td>rā bahasapa-</td><td></td></tr>
<tr><td>tā</td><td></td></tr>
<tr><td>21</td><td></td></tr>
<tr><td>Burhanpur, Latitude 21º 21′</td><td>Devagiri, Latitude 20º 34′</td></tr>
<tr><td>Longitude 113º 0′</td><td>Longitude 111º 0′</td></tr>
<tr><td>Surat, Mumbai,[22] [Lat]20º 20′</td><td>Mecca, Latitude 21º 40′</td></tr>
<tr><td>Longitude 50º</td><td>Longitude 76º 10′</td></tr>
<tr><td>Calcutta, Latitude 22º</td><td>Dwaraka, Latitude 22º 31′</td></tr>
<tr><td>—</td><td>Longitude 56º</td></tr>
<tr><td>Climate 3 Planet Jupiter</td><td></td></tr>
</table>

Plate 5a for the Latitude of 18º

gaṃgāsāgar araj 18||20 *bījāpur araj 17||17* *tūl 118|0* *aklīm dūsarī* *2*	*golkuṃḍā haidarābād araj* *18||0|| tūl 115||19* *yih kā sitārā bi-* *hasapat hai |*
18	
Gangasagar, Latitude 18º 20′ Bijapur, Latitude 17º 17′ Longitude 118º 0′ Climate second	Golconda, Hyderabad, Latitude 18º0′ Longitude 115º 19′ The planet here is Jupiter

Plate 5b for the Latitude of 29º

kuramācala almoḍā ara- *j 28||53||20| tūl* *115||19* *yah aklīm* *tīsarī*	*naipāl araj* 27||10 *tūl 119||25||* *yih kā satārā* *maṃgal hai*
29	
Kumaon, Almoda, Latitude 28º 53′20º, Longitude 115º 19′ This climate is the third	Nepal, Latitude 27º 10′ Longitude 119º 25′ The planet here is Mars.

Plate 6a for the Latitude of 28º 39º

dillī sahar araj 28|39 *tūl 114||18||* *yah aklīm tī-* *sarī hai*	*mathrā araj 26||31||* *tūl 113||30||* *ihā kā satārā maṃga-* *l hai ||*
28|39	
City of Delhi, Latitude 28º 39′ Longitude 114º 18′ This climate is the third.	Mathura, Latitude 26º 31′ Longitude 113º 30′ The planet here is Mars.

The geographical data engraved on these plates is presented in Table 2 below. Here the columns 2, 3, 4 contain the names, latitudes and longitudes of localities as engraved on the plates. Column 4 contains the modern names of localities. In the case of Indian cities, the names of the localities are followed by the names of states in which these localities are situated. In the case of foreign cities, the names of the respective countries are mentioned. Columns 5 and 6 provide the modern values of latitudes and longitudes.[23]

1.2.1 Climates and their Lords

The climate is a relic from Ptolemaic geography, where the inhabited portion of the northern hemisphere was divided into seven climates in such a manner that the maximum duration of daylight at the middle of each climate is half an hour longer than in the previous one, and this notion was adopted by the Islamic world. Malayendu Sūri, who wrote a commentary around 1382 on Mahendra Sūri's *Yantrarāja,* which is the first manual on the astrolabe in Sanskrit and which was composed in 1370 at the court of Fīrūz Shāh Tughluq at Delhi,[24] erroneously thought that the entire northern hemisphere of the earth, from the equator to the North Pole, is divided into seven parts, for he states as follows in the said commentary on the *Yantrarāja*:[25]

> *atha nirakṣāt laṅkāpradeśāt meruparyantaṃ pūrvāpara-dig-vyāpinaḥ sapta vibhāgāḥ tadantarvartināṃ nagaraṇām akṣāṃśa-jñānārtham ādyaiḥ kalpitāḥ santi. teṣāṃ yavanabhāṣayā ikalemeti saṃjñā kṛtā. śani-guru-bhauma-ravi-śukra-budha-somāḥ kramāt svāminaḥ. evaṃ nirakṣa-laṅkā-pradeśāt pratibhāgam akṣāṃśāḥ trayodaśa navaliptābhir nyūnāḥ 12|51 madhyarekhātaḥ pūrvāpara-bhāgasthā bhavanti. evaṃ yantrāṃśāh trayodaśa 13, ṣaḍviṃśatiḥ 26, ekonacatvāriṃśat 39, dvipañcāśat 52, pañcaṣaṣṭiḥ 65, aṣṭasaptatiḥ 78, navatiḥ 90 paryantāḥ. anenaiva krameṇa saptabhāgāḥ syuḥ. paraṃ dvipañcāśad akṣāṃśān yāvan manuṣyāṇāṃ nivāsaḥ. tadagrataḥ ṣaṭ-ṣaṣṭyaṃśa-paryantaṃ śīta-bāhulyād andhakārāc ca manuṣyāṇām alpa eva saṃcāraḥ. tatparataḥ kiṃnara-gandharva-vidyādhara-siddhānāṃ pracārā devabhūmayaḥ.*
>
> "From the equator (*laṅkā*) at 0º latitude (*nirakṣa*) up to the North Pole (*meru*), seven divisions that stretch to the east and west have been conceived by the ancients for knowing the latitudes (*akṣāṃśa*) of the cities which lie in these divisions. They were given the designation of *iklīm* in Arabic language. The lords of these [divisions] are Saturn, Jupiter, Mars, the Sun, Venus, Mercury and the Moon respectively. Thus, [starting]

Table 2: Geographical Data engraved on the Plates

S. No.	Name of the Locality	Lat	Long	Modern Name	Lat N	Long E
1	Paṭīālā	30º 13′	111º 30′	Patiala, Punjab	30º 20′	76º 24′
2	Kurukhetra	30º 10′	112º 00′	Kurukshetra, Haryana	30º 00′	76º 27
3	Naṃdan	52º	—	London, UK	51º 30′	00º 07′
4	Dūsarī					
	Duvārakā	24º 45′	59º	?		
5	Madīnā	25º 0′	75º	Medina, Saudi Arabia	24º 28′	39º 36′
6	Lāhaur	31º 50′	109º 20′	Lahore, Pakistan	31º 32′	74º 20′
7	Kaṃdhār	33º 0′	107º 40′	Kandahar, Afghanistan	31º 37′	65º 43′
8	Kāsmīr	35º 1′	108º	Srinagar, J&K	34º 05′	74º 48′
9	Kābal	34º 30′	104º 40′	Kabul, Afghanistan	34º 31′	69º 10′
10	Ajodhyā	27º 22′	115º 50′	Ayodhya, UP	26º 48′	82º 12′
11	Prayāg Tīrath	26º 50′	115º 34′	Allahabad, UP	26º 59′	79º 00′
12	Misr	30º 30′	63º 1′	Cairo, Egypt	30º 03′	31º 15′
13	Multān	29º 40′	107º 35′	Multān, Pakistan	30º 11′	71º 28′
14	Burhānpur	21º 21′	113º 0′	Burhanpur, MP	21º 18′	76º 13′
15	Sūrat	20º 0′	50º	Sūrat, Gujarat	20º 58′	72º 54º
16	Baṃbai	20º 0′	50º	Mumbai, Maharashtra	18º 58′	72º 49′
17	Kalakatā	22º	—	Kolkata, WB	22º 34′	88º 22′
18	Devagiri	20º 34′	111º 0′	Daulatabad, Maharashtra	19º 56′	75º 14′
19	Makkā	21º 40′	76º 10′	Mecca, Saudi Arabia	21º 25′	39º 49′
20	Duārak	22º 31′	56º	Dwarka, Gujarat	22º 14′	69º 01′
21	Gaṃgāsāgar	18º 20′	—	Gangasagar, WB	21º 48′	88º 06′
22	Bījāpur	17º 17′	118º 0′	Bijapur, Karnataka	16º 50′	75º 42′
23	Golkuṃḍā/					
	Haidarābād	18º 0′	115º 19′	Hyderabad, AP	17º 22′	78º 28′
24	Kurmācal/ Almoḍā	28º 53′20″	115º 19′	Almora, Kumaon Uttarakhand	29º 37′	79º 40′
25	Naipāl	27º 10′	119º 25′	Kathmandu, Nepal	27º 43′	85º 19′
26	Dillī	28º 39	114º 18′	Delhi	28º 40′	77º 13′
27	Mathrā	26º 31	113º 30′	Mathura, UP	27º 28′	77º 41′

from the equator at 0º latitude, each division covers a stretch of 13º of latitude less 9 minutes, i.e. 12º 51′, to the east and west of the prime meridian (*madhya-rekhā*). Thus [these seven divisions reach roughly] up to 13, 26, 39, 52, 65, 78 and 90 degrees of the instrument. The seven divisions follow the same sequence. However, human habitation obtains [only] up to 52º. Beyond this, up to 66º, there is little habitation of humans because of excessive cold and darkness. Thereafter, there are the lands of gods (*devabhūmayaḥ*) where Kiṃnaras, Gandharvas, Vidyādharas and Siddhas[26] dwell."

But, unlike Malayendu Sūri, Abū al-Faḍl explains correctly the system of the climates in the third volume of his *Āī'in-i Akbarī* and also mentions the latitudes at the beginning and middle of each climate and the duration of the longest days at these climates.[27] Such data in tabular form is engraved on the back of some Indo-Persian astrolabes.[28] The latitude values for the boundaries vary according to the value given to the obliquity of the ecliptic.[29] However, on the astrolabe plates, the climate is not mentioned along with the latitude of a locality, as is done on the present astrolabe. It is also obvious that the person who designed this astrolabe follows Malayendu Sūri's erroneous interpretation of the system, for it is only according to Malayandu Sūri that London on the latitude of 52º could belong to the fourth climate. In the correct system, however, London would lie beyond the boundary of the seventh and final climate which varies between 49º 52′ and 50º 33′.[30] The lords of the climates mentioned on the plates are also according to Malayendu Sūri. The instrument maker made an error in the climate number of plate 4b. The plate is calibrated for the latitude of 21º and the climate is given there as 3, but it should be 2. The lord is mentioned correctly as Jupiter.

1.3 The Geographical Gazetteer

All Indo-Persian astrolabes and some Sanskrit astrolabes carry on the inner surface of the mater an elaborate geographical table or gazetteer containing the names, latitudes and longitudes of several localities in India and Central Asia. While the geographical data engraved on the plates is essential for the use of the astrolabe, the geographical gazetteer has no immediate connection with the use of the astrolabe. It is engraved just as a kind of *aide-mémoire*. Even so, such lists are historically important. Though the values themselves are not of great significance, these lists of geographical coordinates of places give us an idea of the transmission of the geographical knowledge and also how certain wrong or inaccurate ideas are perpetuated because authors sometimes borrow data uncritically from the earlier sources. An interesting aspect of these lists is that sometimes the name of a region stands for the capital city; e.g. Kashmir for Srinagar, Tibet for Lhasa, Nepal for Kathmandu, or Tailang/Tilang for Golconda (modern Hyderabad). Sometimes wrong values are perpetuated, e.g. Uḍīsā, in the sense of Puri Jagannath, the principal city of Orissa, is generally given a high value of 27º while the correct latitude is 19º 48′.[31]

Fig. 4. Geographical Gazetteer on the inner side of the Mater

In the present astrolabe, a geographical gazetteer is engraved on the inner side of the mater, continuously in five annular rings, containing the names and latitudes (but not longitudes) of 62 localities (Fig. 4). It is reproduced in Table 3 below.

The last two entries refer to the boundaries of China and Russia. About China it is stated *cīn āraṃbh pūrab* 21º 0′; *cīn had uttar* 55º 0′, "the beginning of China in the east 21º; the boundary of China in the north 55º." This is roughly correct, because the southernmost tip of the land mass of China extends in the east up to the latitude of 21º and its northern boundary reaches up to about 53º. About Russia it is stated: *rūs āraṃbhā 40º 0′ rūs had uttar 66º*, "the beginning of Russia is 40º 00′; the boundary of Russia in the north 66º." In Central Asia, the Russian empire reached up to the latitude of 40º, but in the north it extends much beyond 66º.

The notion of latitude 66º as the boundary of the inhabited world is expressed in Ring V, in what appears to be a mixture of Punjabi and Sanskrit:

Table 3: Geographical Gazetteer engraved on the Mater

S. No.	Name of the Locality	Latitude	Modern Name	Modern Latitude N	Modern Longitude E
			Ring I		
1	Laṃkā[32]	1º 30′	Sri Lanka	06º -10º	80º -82º
2	Pūrabaṃ yamkoṭi[33]	5º 0′	?		
3	Somnāth	16º	Somnath, Gujarat	20º 53′	70º 24′
4	Bījāpar	17º 17′	Bijapur, Karnataka	16º 50′	75º 42′
5	Tailang	18º 0′	Hyderabad, AP	17º 22′	78º 28′
6	Gaṃgāsāgar	18º 20′	Gangasagar, WB	21º 38′	88º 05′
7	Golakuṃḍā	18º 0′	Hyderabad, AP	17º 22′	78º 28′
8	Sūrat	20º 0′	Surat, Gujarat	20º 56′	72º 54′
	Baṃbaī	20º 0′	Mumbai, Maharashtra	18º 58′	72º 49′
9	Devgirī	20º 34′	Daulatabad, Maharashtra	19º 56′	75º 14′
10	Burhānpur	21º 21′	Burhanpur, MP	21º 18′	76º 13′
11	Makā	21º 40′	Mecca, Saudi Arabia	21º 25′	39º 49′
12	Ḍhākā Baṃgālā	22º 0′	Dhaka, Bangladesh	23º 43′	90º 24′
13	Kalakatā	22º 0′	Kolkata, WB	22º 34′	88º 22′
14	Bhurākachā	22º 0′	Bharuch, Gujarat	21º 42′	72º 58′
15	Raivatakācal[34]	22º 31′	Girnar, Gujarat	21º 29′	70º 30′
16	Ahamadābād	23º 0′	Ahmedabad, Gujarat	23º 01′	72º 37′
17	Baḍā(?)yac	23º 0′	?		
18	Ujjain	23º 30′	Ujjain, MP	23º 10′	75º 46′
19	Khaibar	24º 0′	Khybar Pass, Pakistan	34º 06′	71º 05′
20	Madīnā	25º 0′	Medina, Saudi Arabia	24º 28′	39º 36′
21	Ajmer	26º 0′	Ajmer, Rajasthan	26º 26′	74º 37′
22	Kāsī	26º 15′	Varanasi, UP	25º 19′	83º 00′
			Ring II		
23	Dhārā	26º 20′	Dhar, MP	22º 36′	75º 17′
24	Kanaṃj	26º 20′	Kannauj, UP	27º 03′	79º 55′
25	Bīkāner	26º 24′	Bikaner, Rajasthan	28º 01′	73º 17′
26	Gvāliyar	26º 30′	Gwalior, MP	26º 13′	78º 10′
27	Mathrā	26º 31′	Mathura, UP	27º 30′	77º 41′
28	Jodhpur	26º 36′	Jodhpur, Rajasthan	26º 17′	73º 02′
29	Āgarā	26º 43′	Agra, UP	27º 10′	78º 01′
30	Jaipur	26º 47′	Jaipur, Rajasthan	26º 55′	75º 49′
31	Gājīpur[35]	27º 01′	?		
32	Lakhanaū	26º 30′	Lucknow, UP	26º 51′	80º 55′
33	Uḍīsā	27º	Puri, Orissa	19º 48º	85º 51′
34	Ajudhyā	27º 22′	Ayodhya, UP	26º 48′	82º 12′

S. No.	Name of the Locality	Latitude	Modern Name	Modern Latitude N	Modern Longitude E
35	Koil	28º 0′	Aligarh, UP	28º 02′	78º 17′
36	Naipāl	28º 50′	Kathmandu, Nepal	27º 43′	85º 19′
37	Dilī	28º 40′	Delhi	28º 36′	77º 13′
38	Kumāū	28º53′20″	Almora, Kumaon Uttarakhand	29º 37′	79º 40′
39	Hisār	29º 40′	Hissar, Haryana	29º 10′	75º 43′
40	Multānā	29º 40′	Multan, Pakistan	30º 11′	71º 28′
			Ring III		
41	Kurukhetra	30º 10′	Kurukshetra, Haryana	30º 00′	76º 27′
42	Paṭīyālā	30º 13′	Patiala, Punjab	30º 20′	76º 24′
43	Misar	30º 30′	Cairo, Egypt	30º 03′	31º 15′
44	Lāhūr	31º 50′	Lahore, Pakistan	31º 32′	74º 20′
45	Khaṃdhār	33º	Kandahar, Afghanistan	31º 37′	65º 43′
46	Kābil	34º 30′	Kabul, Afghanistan	34º 31′	69º 10′
47	Kāsmīr	35º 1′	Srinagar, J&K	34º 05′	74º 48′
48	Balap	36º 41′	Balkh, Afghanistan	36º 45′	66º 54′
49	Bhoṭalāvācīna[36]	37º 0′	?		
50	Tavrej	38º 0′	Tabriz, Iran	38º 04′	46º 18′
51	Samrkaṃd	39º 34′	Samarqand, Uzbekistan	39º 39′	66º 57′
52	Tibat	40º 0′	Lhasa, Tibet	29º 39′	91º 07′
53	Kubīnā	41º 01′	?		
54	Khutan	42º 0′	Khotan, China	37º 04′	80º 02′
			Ring IV		
55	Kāsgar	44º 0′	Kashgar, China	39º 20′	74º 04′
56	Kurkurūm[37]	46º 0′			
57	Bulgār[38]	49º 0′			
58	Iṃglistān Naṃdan	52º 0′	London, England	51º 30′	0º 05′
59	Cīn āraṃbh pūrab	21º 0′			
60	Cīn had uttar	55º 0′			
61	Rūs āraṃbhā	40º 0′			
62	Rūs had uttar	66º			

daraje 66 uprāt pācbhaut kā cārābhāvaḥ | had 90 devabhūmi (?) This roughly translates to "Beyond the degrees 66 [of latitude] there is an absence of the movement of live beings. [Up to the] boundary of 90 [degrees, it is] the land of gods." Here the instrument is merely reflecting the Ptolemaic notion of the oecumene or the inhabited world, as understood in medieval Sanskrit texts.

Nearly all the localities, save four (viz. Dūsarī Duārakā, Prayāg Tīrath, Duārak and Mathrā), which are mentioned on the plates are repeated in the gazetteer. In one case, there is a substantial difference: the latitude of Nepal is engraved as 27º 10′ on the plate whereas it has a much higher value of 28º 50′ in the gazetteer. The latitude of Delhi is given as 28º 39′ on plate 6a (this is the traditional value from at least 1370); it is rounded off to 28º 40′ in the gazetteer.

1.4 The Back of the Astrolabe

The back of the astrolabe is divided into four quadrants by the vertical and horizontal diameters (Fig. 5). Here the upper half of the rim carries a degree scale. The inner band of the scale is divided into single degrees and the upper band into groups of 6º and labelled as 6, 12, … 90; 90 …12, 6. This is the scale on which the altitudes of the heavenly bodies are measured by means of the alidade. The rim around the lower left quadrant is blank, but the one around the lower right quadrant carries a tangent scale. The outer band is divided into unequal units carrying the numbers 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, starting from the vertical diameter and proceeding towards the horizontal diameter. Each of these divisions is further sub-divided into 5 units in the inner band.

The upper left quadrant bears a sine-cosine grid, consisting of 30 vertical parallels and 30 horizontal parallels. Shadow squares or tangent and co-tangent tables are engraved in the two lower quadrants. The square on the left is for a gnomon of 12. Here both the horizontal and vertical scales are divided into 12 divisions each and numbered accordingly. These divisions are further subdivided into 2 units in the outer band. Below the horizontal scale is engraved the label *narabhā saralā*, "gnomon shadow, straight," (i.e. umbra recta) and to the left of the vertical scale is the label *narabhā pratilomā*, "gnomon shadow, reverse" (i.e. umbra versa).

The square on the right is meant for a gnomon of 7 feet. Here both the horizontal and vertical scales are divided into 7 divisions each and numbered accordingly. These divisions are further subdivided into 2 units in the outer band. Below the horizontal scale is engraved the label *padachāyā*, "shadow of feet, straight," and to the right of the vertical scale is the label *pādachāyā pratilomā*, "shadow of feet, reverse".

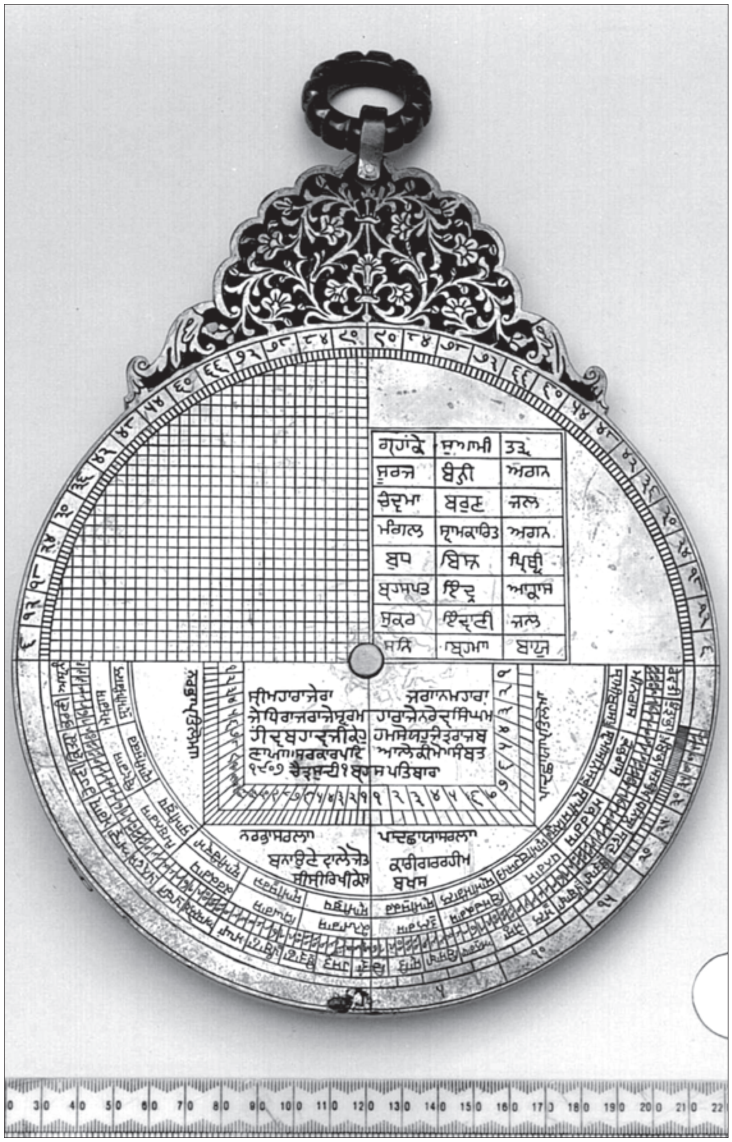

Fig. 5. The Back of the Astrolabe

Islamic astrolabes make a distinction between two kinds of shadows, viz., *zill-i aṣābi'a*, "shadow in digits," and *zill-i aqdām*, "shadow in feet". The first are the shadows thrown by a gnomon which is divided into 12 "digits" and the second are those cast by a gnomon divided into 7 "feet".

Sanskrit astrolabes generally ignore this distinction and call both units of measurement as "*aṅgula*". Thus they call the two kinds of shadows as *dvādaśāṅgula-śaṅku-chāyā*, "shadow cast by a gnomon of 12 *aṅgulas*," and *saptāṅgula-śaṅku-chāyā*, "shadow cast by a gnomon of 7 *aṅgulas*". The present astrolabe maintains the distinction and calls the shadow cast by a gnomon of 12 digits as *narabhā* and that of a gnomon of 7 feet as *pādachāyā*.

Besides these trigonometric tables, the back of the astrolabe carries much astrological data. Indo-Persian astrolabes contain such astrological tables on the back,[39] but Sanskrit astrolabes usually do not. Plate 6b also carries astrological data. The astrological data in both these places appear to have been derived from sources like Kalyāṇavarman's *Sārāvalī* (ca. 800).[40] Like the geographical gazetteer, these astrological tables also do not have any direct bearing on the functions of the astrolabe. These are incorporated into the astrolabes, like the geographical gazetteer, as *aide-mémoires.*

1.4.1 Astrological Data on the Back of the Astrolabe

The upper right quadrant contains a table showing the lords or the presiding deities (*suāmī*, Sanskrit *svāmī*) and the essence or the related element (*tatba*, Sanskrit *tattva*) of the 7 planets (*grah*), which is reproduced below.

Grahā ke (of the planet)	*Suāmī* (lord)	*Tatba* (essence)
Sūraj (the Sun)	*Baṃnhī* (Vahni)	*Agan* (fire)
Caṃdramā (the Moon)	*Baruṇ* (Varuṇa)	*Jal* (water)
Maṃgal (Mars)	*Svāmakārita* (?)[41]	*Agan* (fire)
Budh (Mercury)	*Bisn* (Viṣṇu)	*Prithbī* (earth)
Brahaspat (Jupiter)	*Iṃdra* (Indra)	*Ākās* (ether)
Sukar (Venus)	*Iṃdrāṇī* (Indrāṇī)	*Jal* (water)
Sani (Saturn)	*Brahamā* (Brahmā)	*Vāyu* (wind)

In the lower half, the shadow squares are enclosed by four concentric semi-circles. Reading from outside and from the right to the left, these semi-circles contain respectively

1. the names of the 27 lunar mansions (*nakṣatras*);

2. *nakṣatra-pādas*, i.e. one-fourth parts of the *nakṣatras*, but labelled for each three successive *nakṣatras*, as 1, 2, 3, … 10, 11, 12. Each 9 of these *nakṣatra-pādas* constitute the related zodiac sign, as shown in the next semi-circle;
3. zodiac signs with a suffix *ºrās* (Sanskrit *rāśi*); and
4. the lords of the signs, with the prefix *svāmī*.

This semi-circular table is an improvement on similar tables in Indo-Persian astrolabes, in so far as it has only 27 lunar mansions and not 28, as it shows the correspondence between the lunar mansions and zodiac signs more graphically through the *nakṣatra-pādas* and as it also adds the lords of the signs. It is interesting that in each scale, the items are to be read from the right to the left, as in Islamic astrolabes.

The names of the 27 lunar mansions engraved here are as follows, with the cognate Sanskrit terms in parentheses: 1. *Asanī* (*Aśvinī*), 2. *Bharaṇī* (*Bharaṇī*), 3. *Kritakā* (*Kṛttikā*), 4. *Rohaṇī* (*Rohiṇī*), 5. *Mragas* (*Mṛgaśirā*), 6. *Ārdrā* (*Ārdrā*), 7. *Punarvas* (*Punarvasu*), 8. *Puṣya* (*Puṣya*), 9. *Aslekh* (*Âśleṣā*), 10. *Maghā* (*Maghā*), 11. *Pūrbā Phā* (*Pūrva-phālgunī*), 12. *Utrā Phā* (*Uttara-phālgunī*), 13. *Hasata* (*Hastā*), 14. *Citrā* (*Citrā*), 15. *Svāti* (*Svāti*), 16. *Visākhā* (*Viśākhā*), 17. *Anurādhā* (*Anurādhā*), 18. *Jesṭhā* (*Jyeṣṭhā*), 19. *Mūla* (*Mūla*), 20. *Pūrbākhā* (*Pūrvāṣāḍhā*), 21. *Utrākhā* (*Uttarāṣāḍhā*), 22. *Sravana* (*Śravaṇa*), 23. *Dhanisṭhā* (*Dhaniṣṭhā*), 24. *Satabhikha* (*Śatabhiṣā*), 25. *Pūrvābhā* (*Pūrva-bhādrapada*), 26. *Utrā bhā* (*Uttara-bhādrapada*), 27. *Revatī* (*Revatī*).

The zodiac signs and their lords mentioned in scales 3 and 4 are as follows:

Mekh Rās: *Svāmī Maṃgal* (Aries: Mars), *Brikh Rās*: *Svāmī Sukar* (Taurus: Venus), *Mithan Rās: Svāmī Budh* (Gemini: Mercury), *Karak Rās: Svāmī Caṃdramā* (Cancer: Moon), *Siṃgh Rās: Svāmī Sūraj* (Leo: Sun), *Kaṃnyā Rās: Svāmī Budh* (Virgo: Mercury), *Tul Rās: Svāmī Sukar* (Libra: Venus), *Brisacak Rās: Svāmī Maṃgal* (Scorpio: Mars), *Dhan Rās: Svāmī Brahaspat* (Sagittarius: Jupiter), *Makar Rās: Svāmī Saniscar* (Capricorn: Saturn), *Kuṃbh Rās: Svāmī Saniscar* (Acquarius: Saturn), *Mīn Rās: Svāmī Brahasapat* (Pisces: Jupiter).[42]

1.4.2 Astrological Data on Plate 6b

Some more astrological data is engraved on the reverse side of Plate 6 (Fig. 6). Here the lower half contains a sine-cosine grid of 30 horizontal and 60 vertical lines. In the upper half there are ten concentric semi-circular columns containing astrological information in tabular form.

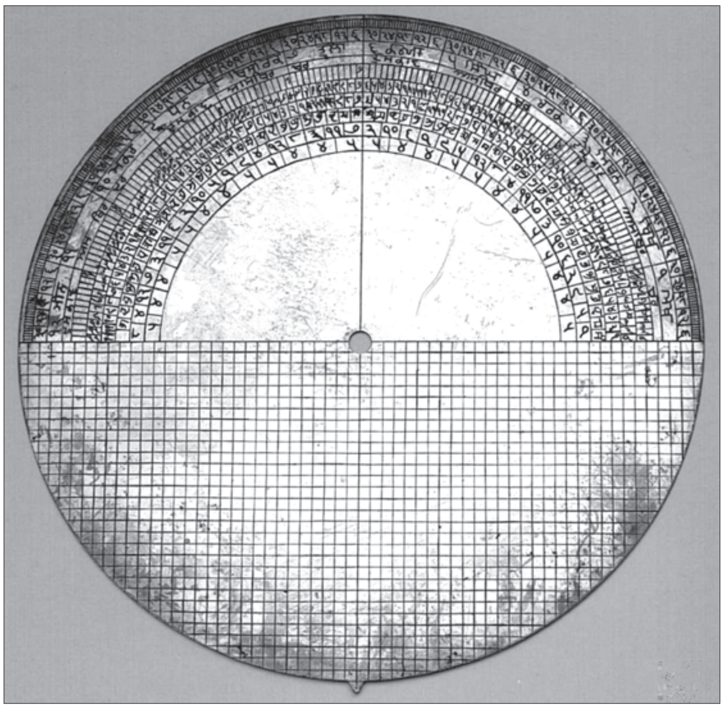

Fig. 6. Plate 6b with astrological tables in the upper half and the sine-cosine grid in the lower half

In Indian astrology, the zodiac signs are sub-divided in ten different ways (*daśa-varga*) and to each part of such a sub-division a planet is assigned as its lord. These combinations are used in making predictions in horoscopy.[43] In the ten semi-circular columns in the upper half, the zodiac signs are divided in different ways. The material in the columns is arranged sometimes from the left to the right and sometimes in the opposite direction. Reading from the outside, these columns contain the following data.

1. Divisions of single degrees.

2. Groups of six degrees labelled as 6, 12, 18, 24, 30 from the right to the left. These are divisions of the zodiac signs in the column below.
3. Twelve zodiac signs, shown by the serial number and the name, written from the right to the left.
4. The same twelve divisions containing a three-fold classification of signs, according to which Aries, Cancer, Libra and Capricorn are said to be *cara* (unsteady), *āsakhira* (?) (steady) and *dasakāva* (?) (mixed).[44]
5. Each sign is subdivided into 12 parts (*dvādaśāṃśa*) of 2½º each. The subdivision on the right bears the same serial number are the zodiac sign, which means that the lord of the sign is also the lord of the first 1/12th division.
6. Each sign is subdivided into 9 parts (*navāṃśa*) of 3 1/3º each. These are numbered from right to left in groups of 12 as 1,2, 3, … 10, 11, 12.
7. Each sign is subdivided into 7 parts (*saptāṃśa*) of 4 2/7º each. These parts are numbered from right to left in groups of 12 as 1, 2, 3, … 10, 11, 12.
8. Each sign is subdivided into 5 parts (*pañcāṃśa*) of 6º each. These parts are labelled with the letters of a mercantile script known as the Lānd script.
9. Each sign is subdivided into 3 parts or decans (*dreṣkāṇa*) of 10º each. The cells are filled with different serial numbers of the signs. For example, the three decans under Aries bear the numerals 1, 5, 9; it means that the lords of the three decans are the same as the lords of the sign nos. 1, 5, 9, viz. Mars, Sun and Jupiter.[45]
10. Each sign is subdivided into 2 parts (*horā*) of 15º each. The cells are filled alternatively with the numerals 4 and 5. These numbers also stand for the lords of the signs bearing these numbers. Thus sign 4 is Cancer and its lord is the Moon; sign 5 is Leo and its lord is the Sun.[46]

1.5 The Alidade

The alidade (length 196 mm) in this astrolabe is surprisingly simple without any decoration or graduations (see Fig. 1). On this alidade, the two sights are affixed, which are rather too close to the centre. There is a pin to hold all the parts together. It is the convention that the wedge that holds the pin firmly in position is shaped like a horse; but here it is shaped like a bird with upraised wings.

1.6 The Inscription on the Back

On the back, inside the shadow squares is an inscription (Fig. 7) which reads thus:

Fig. 7. The inscription on the back of the astrolabe

srī mahārāje rājagāna mahārā-

jedhirāja rājesvara mahārāje nareṃdrasiṃgha ma-

hīṃdra bahādra jī ke huha<ka>m so yahu jaṃtrarāj ba-

ṇāyā || sarkār paṭiyāle kī mo<hur> || saṃbat

1907 caitra sudī 1 brahasapatibār |

"This astrolabe (*jaṃtrarāj*) was made by the order of Srī Mahārāje Rājagāna Mahārājedhirāja-Rājesvara-Mahārāje Nareṃdrasiṃgha Mahīṃdra Bahādrajī. [Under] the Seal of the Government of Patiala. Saṃbat 1907 Caitra sudī 1 Thursday (= Thursday 14 March 1850)."

Below the shadow squares are engraved the names of the designer and of the maker in the left and right halves respectively:

banāūṇevāle jota- *kārīgar rahīm*

sī sī rikhīkes *bakhas*

"He who caused to be made (i.e. he who designed) Jotishī Śrī Rishīkes. The maker (*kārīgar,* lit. artisan) Rahīm Bakhsh."

2.0 Conclusion

Generally Sanskrit astrolabes were designed by Brahmin astronomers who prepared the technical drawings and then they were fabricated by artisans according to these drawings. There is often a mismatch between the two, resulting in uneven graduations and faulty orthography in the inscriptions. In the present case the collaboration between the astrologer Rishīkes and the instrument maker Rahīm Bakhsh was quite successful. Both appear to be familiar with Indo-Persian astrolabes. The latter is a skilful instrument maker. His excellent workmanship can be compared with that of the best astrolabes produced in the Lahore family, in particular the very ornate *kursī*.

One may ask why these people in Punjab produced naked eye instruments in the nineteenth century when telescopes were easily available. It is obvious that they did not consider these instruments purely as tools to be discarded the moment an improved variety becomes available, but treated them as important elements of traditional culture which one cultivated. The local Maharajas of Kaputhala, Patiala and other principalities, patronized these endeavours.

Though the production of astrolabes continued up to the early years of the twentieth century, the present astrolabe is arguably the last important astrolabe produced in India. It is significant that in the production of this astrolabe all three major communities of Punjab took part: the Sikh prince who commissioned the astrolabe, the Hindu astrologer who designed it and the Muslim instrument maker who produced it.

Acknowledgements

I am deeply indebted to the late owner of this astrolabe who graciously allowed me to study this astrolabe and other instruments in his collection and provided me with black and white photographs of high quality, some of which are reproduced with this article. I wish also to thank Dr Jaspal Singh, Cambridge, MA, for his help in the decipherment of the Gurmukhi script and in the translation of the Punjabi sentences on this astrolabe.

Notes and References

1. Cf. Kocchar & Narlikar 1995, pp. 9-14.
2. Cf. Sarma 2001.

3. On Bhālūmal, see Savage-Smith 1985, pp. 52-55, 235-236, 244-245, 304; Sarma 2010a, s.v. Bhālūmal.

4. Cf. Savage-Smith 1985, pp. 235-236.

5. This astrolabe is in the National Museum, New Delhi; it is illustrated in Gupta 1985, p. 179, item 272. There are some other unsigned astrolabes in this museum which can be attributed to Ghulām Qādir on stylistic grounds.

6. Sarma 2003, pp. 78-84; Sarma 2008b, pp. pp. 29-31.

7. See Sarma 2008b, pp. 35-38.

8. For a brief description and an illustration of this double quadrant, see ibid, pp. 33-35.

9. Cf. Sarma 2010b.

10. Christie's 1992, item no. 119, pp. 48-49.

11. For the full text of the inscription and its translation, see section 1.6 below.

12. Rishīkes is the vernacular form of Sanskrit Hṛṣīkeśa. On an Arabic astrolabe that had been reworked with additional inscriptions in Sanskrit, the name of Jyotirvid Hṛṣīkeśa of Kūrmācala (Kumaon) was engraved as the owner of the astrolabe; cf. Sarma 2010a, 75-108, esp. 105-106. Perhaps this Hṛṣīkeśa is the same as the Rishīkes who designed the present Gurmukhi astrolabe.

13. I learnt the Gurmukhi script with the help of a very useful internet resource "Omniglot: writing systems & languages of the world," accessible at http://www.omniglot.com/ and deciphered much of the Gurmukhi engravings on the astrolabe. Subsequently, Dr Jaspal Singh, Cambridge, MA, kindly solved the difficulties in the script and helped me in translating the Punjabi inscriptions.

14. On the history of the astrolabe in India, see Sarma 1994; Sarma 1999; Sarma 2000. On the components of the astrolabe and their functions, see Hartner 1985; North 1974; Khareghat 1950.

15. Cf. Khareghat 1950, pp. 32-39.

16. On climates and their lords, see section 1.2.1 below.

17. Cf. Abū al-Faḍl, *Āī'in-i Akbarī*, vol. 3, pp. 39-40.

18. Cf. Sarma 2000.

19. Cf. Sarma 2011.

20. The Dūsarī Dvārakā or the Second Dvārakā must be an important city, presumably on the West Coast of India, to be allotted a side of a plate. But I fail to locate a city of this name. The longitude value of 59 is clearly too low.

21. This is obviously an error in engraving. Instead of drawing a vertical line to separate the degrees from the minutes, the engraver drew the numeral 1 by mistake.

22. Surat and Mumbai are given the same latitude of 20º 20′ and an absurdly low longitude of 50º, which would place the two cities in Central Africa! Their actual latitudes are more than 2º apart, even though the longitudes are almost the same. See tables 2 and 3 below for the actual values.
23. According to the "Directory of Cities and Towns in World Global Gazetteer," version 2.2., accessible at http://www.fallingrain.com/world/index.html . The seconds in the values of the latitudes and longitudes are omitted here.
24. Cf. Sarma 1999; Sarma 2000.
25. Mahendra Sūri, *Yantrarāja*, p. 18.
26. These are different classes of semi-divine beings of Indian mythology.
27. Abū al-Faḍl, *Āī'in-i Akbarī*, vol. 3, pp. 51-54.
28. Cf. Sarma 2011, p. 98.
29. For a table of climates with corresponding latitudes for different values of obliquity, see King 2005, p. 927.
30. Ibid, p. 927.
31. Cf. Sarma 2011, pp. 93-94.
32. In Indian astronomy, Laṅkā represents the zero latitude and zero longitude. Therefore, it is not clear why the value of 1º 30¹ is given to its latitude. As for the island Sri Lanka, its latitude extends from 6º to 10º .
33. It is difficult to interpret this locality. In Indian astronomy, Yamakoṭi is a notional point on the equator, 90º east of Laṅkā. Then its latitude should be 0º.
34. Raivatakācal, a mountain named Raivataka or Raivata, is mentioned frequently in the epics. Varāhamihira, *Bṛhatsaṃhitā*, 16.19, states that the Raivataka mountain lies in the south-western division. In his interpretation of this passage, Shastri 1996, vol. 1, p. 55, opines that it is the hill opposite Mount Girnar and that it is sometimes identified with Girnar itself.
35. There are several localities named Gazipur in the Indian subcontinent, but none seem to have this value for latitude.
36. The name seems to refer to Tibet (*bhoṭa*) and China (*cīna*) but its exact significance is not known.
37. Karakoram or Karakorum is the name of a mountain range spanning the borders between Pakistan, India and China. The given latitude of 46º is far too high to pertain to any point on this mountain range.
38. The gazetteers on the Indo-Persian and Sanskrit astrolabes end with Bulgār or Bulghar region and city. According to Gibbs & Saliba, p. 201, "the name was given to the land of the Slavs north of the Caspian Sea around the Volga River."
39. Astrological data on the back of Indo-Persian astrolabes is discussed by Kaye 1918, Appendix B: Astrological Tables, pp. 119-126.

40. Cf. Pingree 1971, pp. 26-29; Pingree 1981, p. 88. Several chapters of the *Sārāvalī* have been translated into German by Türstig 1980, pp. 154-294.

41. Kalyāṇavarman, *Sārāvalī* 4.12 states that the lords of the planets are Agni, Varuṇa, Skanda, Viṣṇu, Indra, Śacī and Brahma; cf. Türstig 1980, p. 163. Accordingly the lord of Mars should be Skanda, also known as Kārtikeya and Ṣaṇmātṛka. Is Svāmakārita a corruption of Ṣaṇmātṛka?

42. *Sārāvalī* 3.11; cf. Türstig 1980, p. 157.

43. *Sārāvalī* 1.3; cf. Türstig 1980, pp. 53-66.

44. *Sārāvalī*, 3.20; cf. Türstig 1980, p. 159.

45. *Sārāvalī* 3.14 states that the lords of the three decans of any zodiac sign are respectively the lords of the same sign and of the fifth and ninth signs; cf. Türstig 1980, p. 158.

46. *Sārāvalī* 3.14 states that the lords of the *horās* in a sign with an odd number are the Sun and the Moon respectively and that the lords of the *horās* in a sign with an even number are the Moon and the Sun respectively; cf. Türstig 1980, p. 158.

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