THE MAKERS, DESIGNERS AND PATRONS OF SANSKRIT ASTRONOMICAL INSTRUMENTS - AN ALPHABETICAL DIRECTORY OF NAMES AND RELATED INSCRIPTIONS

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1 Introduction

1.1.1 Indian art is generally anonymous. It is rarely that an artist puts his signature on his creation, be it a stone sculpture, a metal image or a mural painting. We do not know who fashioned the voluptuous figure of the so-called Didarganj Yakṣī which is now in the Patna Museum, or who sculpted the serene icon of the seated Buddha in the *Dharmacakra-pravartana-mudrā* in the Sarnath Museum, who cast the colossal 2.3 m copper statue of the standing Buddha which was found in Sultanganj and which is now in the Birmingham Museum in UK, or who painted all the marvellous frescos in the Ajanta Caves. If at all these art objects carry an inscription, it refers to the object of representation (as on the Yakṣī sculptures at Barhut) or to the donor (as in the case of the massive Bodhisattva image now at Sarnath which was commissioned and donated by the Friar Bala). It is rarer still that the creator of minor art forms such as metal artefacts signs his name on his production.

1.1.2 In the Islamic world, however, it was customary that metal workers put their names on their productions. In this connection Kjeld von Folsach observes as follows:

There is no doubt that metalwork enjoyed great respect in the Muslim world. Precious metals were costly, and in all circumstances metal-working demanded great knowledge and skill. Many prestigious items are preserved with the names and full titles of princes and nobles, and even on more modest pieces one finds-more often than in other groups of objects-the owner's name engraved either at the time of making or in the form of *Wakf* inscriptions added at a later date, when the item was handed over to a particular institution

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Abbreviations used: PC = private collection, PLU = present location unknown; S.V. = sub voce (see under the word mentioned, for the major entry), VS = *Vikrama Saṃvat*.

for all time. Except for the art of the book it is also in the field of metalwork that most artists' names have been recorded, and in that of scientific instruments we nearly always know the name of the maker... In a civilization and period in which few sources exist that throw light on art and artists, signed, dated and located works of art are of great importance to research. These works of art provide the framework for what would otherwise be attributions based predominantly on stylistic features.'[1]

1.1.3 This custom is followed invariably in the case of astronomical instruments made of metal, especially astrolabes and celestial globes. Thus the earliest surviving astrolabe produced in the Islamic world in 927 A.D., bears the name of the instrument maker Nasṭūlus.[2] Likewise the earliest extant celestial globe manufactured in the Islamic world, carries the names of Ibrāhīm ibn Sa'īd al-Sahlī al-Wazzān and his son Muḥammad who produced this globe in Moorish Spain in AH 473 or 478 (= A.D. 1080 or 1085).[3] On the basis of the inscriptions containing the makers' names, scholars have been able to trace the history of instrument making in the Islamic world and in Europe.

1.2.1 In India, various kinds of astronomical instruments were produced and used before the advent of Muslims. But, no actual specimens of these survive today; therefore it is not possible to say whether there existed a custom of writing the names of instrument makers on the instruments. With the introduction of the astrolabes and celestial globes into India,[4]

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1 Kjeld von Folsach, *Islamic Art: The David Collection,* Copenhagen 1990, p. 183. This collection, for example, holds a twelfth-century inkwell of cast bronze inlaid with silver and copper which carries the inscription 'made by Shah Malik' (pp. 194-195, No. 320) and an exquisitely crafted jug of cast brass with inlaid silver and gold on which was engraved the name of the maker 'Alî ibn Muḥammad 'Alī Shahāb al-Ghurī and the year AH 918 (=AD 1512) (p. 207, No. 347.)

2 It is preserved today in the Islamic Archaeological Museum, Kuwait. For a description and illustrations of this astrolabe, cf. David A. King, 'Early Islamic Astronomical Instruments in Kuwaiti Collections' in: Arlene Fullerton & Géza Fehérvári. *Kuwait: Arts and Architecture: A Collections of Essays*, Kuwait 1995, pp. 76-96.

3 It is with the Museum of History of Science at Florence. For a description of this globe, cf. Emilie Savage-Smith, *Islamicate Celestial Globes: Their History, Construction and Use*, Washington, D.C., 1985, p. 271.

4 On this, see Sreeramula Rajeswara Sarma, 'Sultān, Sūri and the Astrolabe,' *Indian Journal of History of Science,* 35.2 (2000) 129-147; reprinted in: idem, *The Archaic and the Exotic: Studies in the History of Indian Astronomical Instruments,* New Delhi 2008, pp. 179-198; idem, 'From al-Kura to Bhagola: On the Dissemination of the Celestial Globe in India,' *Studies in History of Medicine and Science,* 13.1 (1994) 69-85; reprinted in: idem, *The Archaic and the Exotic, op. cit.*, pp. 275-293.

there came also the custom of engraving on them the names of makers. Thus a great majority of surviving Indian astronomical instruments contain the names of the instrument makers, sometimes accompanied by the names of their fathers and other ancestors. With the help of these names, a history of instrument making in India, can also be traced.

1.2.2 For several years, I have been surveying the extant Indian astronomical instruments and have identified so far nearly 450 specimens preserved in museums and private collections in India, Europe and North America.[5] These instruments can be broadly classified into two groups: those with numerals, legends and inscriptions in Arabic/Persian and those with the same in Sanskrit. The former are known as Indo-Persian instruments[6] and the latter as Sanskrit instruments. A study of the inscriptions on the Indo-Persian instruments, shows that most of these were produced during the sixteenth and seventeenth centuries by the members of a single family from Lahore, who were patronized by the Mughal nobility.[7]

1.3.1 Some 200 of the extant specimens are Sanskrit astronomical instruments, carrying various types of inscriptions. As measuring instruments, they contain scales, the divisions of which are labelled with Devanāgarī numerals. Then there are legends mentioning the Sanskrit names of certain lines, circles, and also of zodiac signs, star constellations and individual stars.

1.3.2 In addition to these numbers and legends, some instruments contain inscriptions which provide information about their makers, the designers who prepared the technical drawings, patrons or owners who commissioned or owned instruments. It is with such inscriptions that we are concerned here. Since no other records are available about the actual manufacture of astronomical instruments, these inscriptions are valuable documents for reconstructing the history of the production of astronomical instruments in India.

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5 On this project, see Sreeramula Rajeswara Sarma, 'Indian Astronomical and Time-Measuring Instruments: A Catalogue in Preparation,' *Indian Journal of History of Science,* 29.4 (1994) 507-528; reprinted in: idem, *The Archaic and the Exotic, op. cit.*, pp. 19-46.

6 Not because there is any Persian influence on them, but because they were produced in the Indo-Persian milieu, that is to say, by people who used Persian as the academic language in India.

7 Sreeramula Rajeswara Sarma, 'The Lahore Family of Astrolabists and their Ouvrage,' *Studies in History of Medicine and Science,* 13.2 (1994) 205-224; reprinted in: idem, *The Archaic and the Exotic, op. cit.*, pp. 199-222.

Therefore the full texts of such inscriptions on all the known Sanskrit astronomical instruments will be reproduced in the following pages. With the exception of a few, all the inscriptions have been deciphered and translated by me and collected here for the first time.

1.3.3 The inscriptions are arranged according to the names of the makers, designers and patrons mentioned therein. When there is more than one name in an inscription, the main entry with the inscription will be under the name of the maker or the designer. The names are arranged in Sanskrit alphabetical order. Like many manuscripts, these inscriptions also generally avoid the *parasavarṇa* and employ instead *anusvāras,* which have been retained here as in the original. For the sake of clarity, *avagrahas* have been added silently.

Each inscription will be followed by a translation in English and the details about the instrument on which the inscription is engraved, such as its dimensions and the present location. It is the general convention not to identify the private collectors possessing the instruments. In such cases, the location is indicated as 'PC', meaning private collection. Years without any label, are the years of the Christian era. Dates in other eras are converted into modern Gregorian dates with the help of the online *Pañcāṅga* programme, designed by Professor Michio Yano of Kyoto Sangyo University.[8] There will be comments explaining the purport of the inscriptions or drawing attention to some peculiar features. However, this index will not go into the technical aspects of the instruments and their functions.

1.3.4 In the Islamic world and also among the Muslims of India, making scientific instruments, especially astrolabes, was a highly specialized and respected profession, for these astrolabe makers were not merely brass workers, but also scholars well-versed in astronomy, trigonometry and the theory of instruments. In most cases, the same person prepared the technical design and then produced the instrument in metal according to the design. Among the Hindus, however, the technical design was first prepared and drawn on paper by an astronomer, who was usually a Brahmin, and the instrument was then prepared according to the design by an artisan of a lower caste. When an artisan specializes in a particular trade, he passes on his skills to his descendants. Thus families begin to specialize in a particular product. But instrument making does not seem to have become such a specialized profession among the Hindus.

8 http://www.cc.kyoto-su.ac.jp/~yanom/pancanga/index.html

1.3.5 Though *Jyotiḥśāstra* or the astral science was cultivated and thousands of texts were composed on various branches of the *śāstra* throughout India, it is intriguing that the extant Sanskrit astronomical instruments do not emanate from all parts of India, but only from a small segment of the Indian subcontinent comprising the present states of Gujarat, Rajasthan and Punjab. I am unable to explain this anomaly satisfactorily. The places of production which are mentioned in the inscriptions (or which can be assumed from other evidence) are Ahmedabad, Bhuj, Bundi, Jaipur, Jodhpur, Kota, Kuchaman, Lahore, Patiala and Tonk. From this, it becomes quite clear that in the eighteenth century, not only Sawai Jai Singh was interested in astronomical instruments but several other rulers—of Bundi, Jodhpur, Kota, Kuchaman, Patiala— either commissioned instruments or extended their patronage to instrument makers.

In particular, the city of Kuchaman in the Nagaur district of Rajasthan, deserves notice. It is situated some 130 km west of Jaipur and lies on almost the same latitude (Jaipur 26;55° N, 75;49° E. Kuchaman 27;8° N; 74;50° E). We know of four astrolabes fabricated at Kuchaman by the master artisan Laksmīnārāyaṇa (s.v.) between 1883 and 1903. Two of these astrolabes were designed by the astronomer Jayakṛṣṇadāsa, not for himself, but for another astronomer named Acaleśvara. The two others were designed by Jayakṛṣṇadāsa's son Haridatta. Only one of these four has multiple plates; the other three have single plates calibrated for the latitude of 27°, which can be used at Kuchaman, Jaipur or Agra. Thus this city Kuchaman appears to have had a family of astronomers who could design astrolabes, artisans to fabricate them and also clients to use them, well into the beginning of the twentieth century. There are extant dozens of single plate Sanskrit astrolabes calibrated to the latitude of 27° but without any information engraved on them about the maker or the year of production. Some of these may have been produced in Kuchaman and not necessarily in Jaipur.

1.3.6 The instruments represented here are mainly astrolabes (*yantrarāja*), but there are isolated specimens also of other types like the celestial globe (*bhagola-yantra*), *dhruvabhrama-yantra*, horizontal sundial with triangular gnomon (*palabhā-yantra*), quadrant (*turīya-yantra*), column dial (*cābuka-yantra*) and a variety of quadrant known as the *yantra-cintāmaṇi*.

1.3.7 These Sanskrit inscriptions were composed by the Brahmin astronomers who designed the instruments. The quality of Sanskrit, however, is not always uniform. While some inscriptions are in correct Sanskrit, others are in 'popular' Sanskrit without proper case-endings or with an admixture of Old Gujarati or other vernaculars. Interestingly enough, some of the inscriptions are in verse form. Chronologically, Sawai Madho Singh of Jaipur seems to be the first to sign his instruments in verses. Whether it is due to his influence, or whether the fashion was in the air, many instrument designers of Rajasthan and also of Punjab added metrical signatures to their instruments. These are the following: Sawai Madho Singh of Jaipur (r. 1750-67), Nandarāma Miśra of Kāmyakavana in the Braj region (1767), Motilāla (1785) Gaṅgāsahāya of Tonk (1795), Rāmanātha of Kota (1827), Mannālala of Jaipur (ca. 1850), Vaijanātha's son of Kota (1834), Bhālūmal of Lahore (1839-50), and Gaṅgāsahāya Śiśuka of Bundi (1870). These metrical inscriptions express the years of manufacture in the word numerals.

1.3.8 The Brahmin astronomers who designed the astrolabes use occasionally the titles *jyotirvid* ('one who knows [the science of] the luminaries'), *daivajña* ('one who knows the destiny') or simply *jośī* (from Sanskrit **jyotiṣī*, 'astronomer/astrologer'). The artisans are occasionally referred to as *Śilpin* ('one who practices a craft'). In three cases, persons are mentioned, not by their own names, but as the sons of *x*. Thus a certain Gaṅgāsahāya (s.v.) is known from an interesting astrolabe he designed and caused to be made at Tonk in Rajasthan in 1795. Seventy-five years later another astronomer designed an astrolabe of huge proportions and got it produced at Bundi, also in Rajasthan, precisely on 25 December 1870 to coincide with the birthday of Rāmasiṁha, the ruling prince of Bundi. Now this second astronomer calls himself Gaṅgāsahāya-śiśuka (s.v.), 'the child of Gaṅgāsahāya'. He must indeed be the son of the Gaṅgāsahāya mentioned above and may have reached a ripe old age in 1870. Yet, it is not clear why he does not mention his own name but calls himself merely 'the child of Gaṅgāsahāya'. There are three other such cases. The Adler Planetarium at Chicago possesses a Sanskrit astrolabe, produced by *Jyotirvid* Hṛṣīkeśa (s.v.) for Caṇḍīdatta's son. Another Hṛṣīkeśa (s.v.), also with the title *Jyotirvid*, of Kumaon, seems to have caused the engraving of Sanskrit legends on what was originally an Arabic astrolabe, for the sake of 'Bālādatta's son'. Finally a certain Vaijanātha's son engraved a silver quadrant at Kota in Rajasthan in 1834. It is rather intriguing that in these cases, the astronomers preferred to be known as the sons of their fathers and not by their real names.

1.3.9 The script used in all the instruments is Devanāgarī. There is, however, an important exception. In 1850, Narinder Singh, the *Mahārājā* of Patiala, commissioned an astrolabe which was designed by the astronomer Rishīkesh (s.v.) and made by the artisan Rahīm Bakhsh. The script used on this instrument is Gurumukhī and the language is Punjābī.[9] Two other astronomical instruments with Gurumukhī engravings are known, but they do not carry any date or name. Obviously they too were produced in the same milieu about the same time.

1.3.10 After these introductory remarks, I present below a directory (arranged in the order of the Sanskrit alphabet) of the names of the makers, designers and patrons of Sanskrit astronomical instruments together with the related inscriptions. These names, connected with the design and production of Sanskrit astronomical instruments, deserve a place in the history of science and technology of India.

2 Alphabetical Directory

Acaleśvara, son of *Paṃ[ḍita] Jyotirvid Audīcya* **Mahādeva**, of Kuchaman, owner of two astrolabes made by **Lakṣmīnārāyaṇa** (s.v.) in 1887 and 1902.

Ānandīlāla assisted **Gaṅgāsahāya Śiśuka** (s.v.) in designing a very large astrolabe in 1870.

Indrajī, Jośī, owner of an astrolabe dated vs 1730/AD 1673, one of the earliest extant Sanskrit astrolabes. Pitt Rivers Museum, Oxford, diameter 115 mm.[10] Inscription on the back of the crown:

jośi iṃdrajīkasya yaṃtraṃ
saṃvat 1730 varṣa kārtika śudi 6 bhau

'The instrument (i.e. astrolabe) of Jośī Indrajī, [made] on the sixth day of the bright half of *Kārtika* of the *Saṃvat* year 1730, *Bhau[mavāra]*' (= Tuesday, 17 October 1673).

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9 Discussed and illustrated in: Sreeramula Rajeswara Sarma, 'Indian Astronomical Instruments in German Collections,' XXX. Deutscher Orientalistentag, Freiburg, 24.-28. September 2007. Ausgewählte Vorträge, hrsg. im Auftrag der DMG von Rainer Brunner et al. Online-Publikation, February 2008. http://orient.ruf.uni-freiburg.de/dotpub/sarma.pdf.

10 Robert T. Gunther, 'Oriental Astrolabes' in: idem, *Early Science in Oxford*, vol. II: Astronomy, Oxford 1923, pp. 187-199; idem, *Astrolabes of the World,* Oxford 1932, reprint: London 1976, vol. 1, No. 79, p. 211, fig. 10.

Kalyāṇa, son of **Jagatārasiṃha** of *Girinārāyaṇa-jñāti*, appears to have prepared an astrolabe for **Puruṣottama** in vs 1699 (= AD 1642). Notes and an outline diagram in the archives of the Museum of the History of Science, Oxford. PLU.

Kastūrīcandra instructed **Sūryamalla** (s.v) about the production of an astrolabe.

Kiśorasiṃha, ruler of Kota from 1817-1827 and patron of **Rāmanātha** *Jyotirvid* (s.v.) who made a *dhruvabhrama-yantra* in 1827.

Kīrticandra, ruler of an unidentified kingdom in Rajasthan, for whom **Motilāla** (s.v.) made a *dhruvabhrama-yantra* in 1785.

Keśarīsiṃha, Rao Bahadur, the ruler of Kuchaman during whose reign an astrolabe was designed by **Haridatta**, son of *Jyotirvid* **Jayakṛṣṇa,** and made by Ustāda **Lakṣmīnārāyaṇa** (s.v.) in 1883, and who commissioned a diptych dial by *Jośī* **Rāmacandra** (s.v.) in February/ March 1885. Instruments continued to be made during the reign of Keśarīsiṃha's son and successor **Serasiṃha** (Sher Singh) (s.v.) also.

Keuji Ācārya, Bikaner, probably owned an astrolabe, at the back of which his name was scratched, Single plate for latitude 28°, 20 star pointers, d. 206. At the back only the sine-cosine grid is engraved on the top quadrant. The remaining three quadrants are blank. (Photographs in the archives of the Museum of the History of Science, Oxford).

Gaṅgāsahāya caused an astrolabe to be made by **Rāmapratāpa** at Tonk (26;11°N; 75;50° E, Rajasthan) in vs 1852/AD 1795. PLU. Photographs in the archives of the Museum of the History of Science, Oxford. Single plate for the latitude 26°N, diameter 334 mm. Several inscriptions can be read from the photographs.

On the obverse side of the crown:

śrībundi-pṛthvīśvara-satkṛto yaḥ
śrītātapādārcanalabdhavidyaḥ ।
gaṃgāsahāyo 'racayat sayatnaṃ
rāmapratāpābhidaśilpinādaḥ ॥1॥ [metre: *Indravajrā*]
Saṃvat 1852.

'Gaṅgāsahāya, who was honoured by the glorious king of Bundi, and who received [all] the sciences through the worship of [his] father's feet, [caused to be] constructed this [astrolabe] with [great] effort through the artisan named Rāmapratāpa. vs 1852.'

Below the rete, partly obscured by it:

ṭākanagare palabhā 5/54

'kṣāṃśāḥ 26 pala[karṇa]

'In the city of Ṭāka [Tonk] the latitude degrees are 26; equinoctial shadow 5154, equinoctial [hypotenuse ...].'

On the lower rim of the rete:

idaṃ patraṃ bhacakrapatraṃ । asya madhye tu

rāśicakrayutaṃ krāntimaṇḍalaṃ ।

asmin patre siddhāntānusārāṃṇy eva nakṣatrāṇi.

'This plate [is called] the plate of the stellar sphere (*bhacakrapatra*). In it is [engraved or situated] the ecliptic ring (*krāntimaṇḍala*) together with the circle of the zodiac (*rāśicakra*). On this plate the star positions are [marked] strictly according to the *siddhāntas* (i.e. Sanskrit astronomical tradition).'

The projections on the back are unusual. An inscription on the crown states that

cakra-turīya-phalaka-yantrāṇām ekatra samāveśaḥ.

'[Here are] assembled at one place the *cakra-yantra,* the quadrant (*turīya-yantra*), and the *phalaka-yantra.*'

Upper left quadrant reads:

ṭoṃkanagare

phalaka-yantra-yogya ।

paramā yaṣṭiḥ 36/34.

'In the city of Tonk, the maximum altitude (*paramayaṣṭiḥ*) appropriate for the *phalaka-yantra* is 36/34.'

Upper right quadrant

phalaka-yantra

carajyā-khaṇḍāḥ

3/2/2

6/18/2.

'Accensional differences for the *phalaka-yantra* are 3/2/2 and 6/18/2.'

It is interesting to note that there are projections of *turīya-yantra, cakra-yantra* and *phalaka-yantra* on the back of this astrolabe. A *turīya-yantra* (i.e. a quadrant) is normally incorporated on the back of the astrolabe for measuring the altitudes of the heavenly bodies. The back of the astrolabe can also function as the *cakra-yantra,* which is a graduated circle with an upright peg at the centre.[11] But a *phalaka-yantra* is not a part of the astrolabe. Invented by Bhāskara II,[12] it is a rectangular board on which are drawn a number of horizontal parallels. A peg is attached at the centre of the board at right angles to the surface of the board and a circle is drawn with the peg as the centre. The shadow of the peg falling on the circle and on the parallel lines enables the astronomer to determine graphically time and other elements.[13] However, not a single specimen of the *phalaka-yantra* has survived.[14] Therefore Gaṅgāsahāya's attempt at using the back of the astrolabe as a *phalaka-yantra* is historically valuable. For this purpose, starting a little above the centre, he draws a number of equi-distant horizontal parallels up to the centre and beyond

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11 It was described by Brahmagupta in his *Brāhmasphuṭasiddhānta* 22.18, by Lalla in *Śiṣyadhīvṛddhidatantra* 21.18-21 and by Bhāskara II in *Siddhāntaśiromaṇi, Golādhyāya, Yantrādhyāya,* 10-15ab. Commenting on Bhāskara II's treatment of the *Cakrayantra,* Nṛsiṃha Daivajña remarks: *idam eva cakrayantram akṣapatra-bhapatrayutaṃ yantrarāja ity āhuḥ,* 'The same graduated disc (*cakra-yantra*), when equipped with latitude plates (*akṣa-patra*) and rete (*bha-patra*), is called the astrolabe (*yantrarāja*),' cf. *Siddhānta-śiromaṇi of Bhāskarācārya with his autocommentary Vāsanābhāṣya & Vārttika of Nṛsiṃha Daivajña.* ed. by Murali Dhara Chaturvedi, Varanasi 1981, p. 444. Of course, Nṛsiṃha is well aware that the transition from a graduated disc to the astrolabe is not that simple. Immediately after this remark, he proceeds to describe the construction and use of the astrolabe in great detail, citing extensively from Rāmacandra Vājapeyin's *Yantraprakāśa* and Mahendra Sūri's *Yantrarāja* (*ibid,* pp.445-456).

12 *Siddhāntaśiromaṇi, Golādhyāya, Yantrādhyāya* 16-22.

13 Cf. Yukio Ôhashi, 'Astronomical Instruments of Bhāskara II and After' in: B. V. Subbarayappa & S. R. N. Murthy (ed), *Scientific Heritage of India,* Bangalore 1988, pp. 19-23, esp. 20: '*Phalaka-yantra* is Bhāskara II's invention, and is an instrument for both observation and graphical calculation. It is a rectangular board whose height is 90 *aṅgulas* and the breadth 180 *aṅgulas.* Horizontal lines are drawn at every *aṅgula,* and a hole is made at the middle of the 30th line from upside in order to place a pin. A circle with a radius of 30 *aṅgulas* is drawn from the hole as centre. Its circumference is graduated with *ghaṭīs* and degrees. An index arm is suspended by the pin. Firstly the sun's altitude is observed by this instrument, then correction of ascensional difference is done graphically in order to determine time.' See also idem, 'Astronomical Instruments in India' in: Helaine Selin (ed), *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures* (2nd edition), Springer, 2008, pp. 269-273, esp. p. 270; Fig. 1 on p. 272 shows a hypothetical reconstruction of the instrument.

14 In 1885, Rāmacandra (s.v.) Joṣī of Kuchaman incorporated a *phalaka-yantra* in a diptych dial.

up to the lower periphery. Two concentric circles with different radii are drawn from the centre. How this arrangement can be used simultaneously as *turīya-yantra, cakra-yantra* and *phalaka-yantra* will be discussed elsewhere. Here it remains to be added that unfortunately we do not know the present location of this unique Sanskrit astrolabe designed by Gaṅgāsahāya in 1895. Our information is based on two photographs in the archives of the Museum of the History of Science at Oxford.

Gaṅgāsahāya-śiśuka caused a very large astrolabe to be made by the artisan (*śilpin*) **Śivalāla** at Bundi (25;27°N; 75;41°E), Rajasthan, in vs 1927 *Pauṣa śuddha* 3 (= Sunday, 25 December 1870) on the birthday of the ruler **Rāmasiṃha**. It has a single plate calibrated for the latitude of Bundi at 25;30°, preserved at the Science Museum, London. It is a huge instrument with a diameter of 662 mm. It cannot be held aloft in one hand for the purpose of observation; it is obviously designed for demonstration and teaching. The names of many circles are written and explained. The inscription on the crown reads thus (Figure 1):

śrīparameśvarāya namo namaḥ
bhanavendumite 1927 vikrama-
varṣe pauṣe site tṛtīyāyāṃ [।]
śrī-rāmasiṃhavarddhāpana-
divase yantrarājapūrttir abhūt 1 [॥][15] [metre: *Gīti*]
skandhe kutūhalavato gaṇitābhidhāne
śrīrāmasiṃhadharaṇīśanideśabhājaḥ ।
gaṅgāsahāya-śiśukasya matena saumyaṃ
śrīyaṃtrarājam atanoc chivalālaśilpī 1 [॥] [metre: *Vasantatilakā*]
gaṅgāsahāya-śiśuka-khedaccheda-sahāyatāṃ (°*kheṭa-cchedya*° ?) [।]
gaṇite 'bhajad ānandīlālaś chaganalāla-yuk 1 [॥] [metre: *Anuṣṭubh,* irregular]
saumyanāmā yantrarājaḥ

'Salutation, salutation to the glorious Parameśvara. In the *Vikrama* year measured by the lunar mansions (*bha* = 27), nine (*nava* = 9) and the moon (*indu* = 1) (i.e. 1927), on the third day of the bright fortnight in the month of *Pauṣa*, on the birthday of the glorious Rāmasiṃha, this instrument was completed.

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15 Here and below, instead of the double *daṇḍa*, the engraver employs a symbol which resembles the Devanāgarī numeral 1.

'The artisan Śivalāla constructed this glorious northern (*saumya*) astrolabe (*yantrarāja*) according to the design (*mata*, lit. view) of Gaṅgāsahāya-*śiśuka* who was interested in the branch called mathematical astronomy (*gaṇita*) and who received orders [to construct this astrolabe] from the glorious king Rāmasiṃha.

'Ānandīlāla, accompanied by Chaganalāla, rendered assistance in the mathematical computations (*gaṇita*) to Gaṅgāsahāya-*śiśuka* in [connection with] the drawings of astronomical projections (*kheṭa-cchedya* ?).'

'An astrolabe (*yantrarāja*) by name the Northern [variety] (*saumyanāmā*)

There are two sets of legends on the rete. While the former refer to the star positions marked according to Sanskrit astronomical tradition (*siddhānta*), the latter to those marked according to Islamic astronomical tradition (*yavanamata*). On the back is engraved the entire fifth chapter of Mahendra Sūri's manual on the astrolabe entitled *Yantrarāja.*[16] This chapter, called *Yantravicāraṇādhyāya* teaches how to use the astrolabe for observation and for computation and for solving diverse kinds of problems.

Perhaps this person is the son of Gaṅgāsahāya (s.v.), but *Gaṇgāsahāya-Śiśuka* (lit. Gaṅgāsahāya's infant) is a strange expression.

Gajasiṃha, ruler of Jodhpur from 1619 to 1639 and patron of **Cakrapāṇi** (s.v.) who made an astrolabe in 1625.

Gokulanātha Śarmā made, or more probably designed, a horizontal sundial with a triangular gnomon (*palabhā-yantra*) in pink sandstone in vs 1939/AD 1882. Jaipur Observatory. Inscription:

idaṃ palabhāyatraṃ । gokulanāthaśarmmaṇā । racitaṃ saṃvat 1939 ।
atra nataghaṭikā jñeyāḥ ।

'This *palabhā-yantra* was made by Gokulanātha Śarmā. Saṃvat 1939 (=AD 1882). Here [the divisions on the dial] are to be known as *ghaṭikās* up to/from the noon (*nata-ghaṭikā*).'

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16 Kṛṣṇaśaṃkara Keṣavarāma Raikva (ed), *Yantrarāja of Mahendra Sūri, together with the commentary of Malayendu Sūri and Yantraśiromaṇi of Viśrāma*, Bombay 1936.

Cakrapāṇi, son of **Viśvanātha**, made at Jodhpur in 1625 during the reign of **Gajasiṃha,** an astrolabe with a diameter of 108 mm of which only the mater survives. In 2002, it was auctioned by Skinner, Bolton, USA. [17] PLU. Inscription engraved on the crown and continued on the rim for about three quarters:

śrīsaṃ. 1682 varṣe mārgaśira śu 1 ravau mahārājādhirājamahārāja-śrī-gajasiṃhajī-vijayarājye pokaraṇījñātīyapra. śrī-viśvanāthātmaja-śrī-cakrapāṇinā kṛtam idaṃ [sic! read *ayaṃ*] *yantrarājaḥ* ॥*śrī*॥

'In the glorious *Saṃvat* year 1682, on Sunday, the first day of the bright half of *Mārgaśirṣa* (= 30 November 1625) in the victorious reign of *Mahārājādhirāja Mahārāja* Gajasiṃhajī, this astrolabe was made by glorious Cakrapāṇi, son of glorious Viśvanātha of the Pokaraṇī-*jñāti*.'

Caṇḍīdatta. For Caṇḍīdatta's son, a *yantra-cintāmaṇi* was made by the astrologer **Hṛṣīkeśa** (s.v.).

Caṇḍīdāsa (probably designed and) commissioned an astrolabe for his son **Dāmodara** in 1605 at Ahmedabad, during the reign of the Mughal emperor Jahāṅgīra. It is a massive astrolabe with a diameter of 276 mm and six plates. It was formerly with the Time Museum, Rockford; now in a private collection at Brussels.[18] This is the earliest extant Sanskrit astrolabe and is very important for the history of Sanskrit astrolabes. Inscription on the inner side of the mater:

śrīgaṇādhipati[r] jayatu ॥

svasti śrī saṃvat 1663 varṣe śāke 1528 pravarttamāne māghavadi 1 pratipadātithau ravidine amadāvādanagare mahāsuratrāṇa pātasāha śrī salīma-sāha-rājye yaṃtrarāja jo° caṇḍidāsaiṃ karāvyu । purtra damodara paṭhanārthaṃ ॥ *śubhaṃ bhavatu* ॥

17 Skinner, *Science & Technology, featuring Mechanical Music* (Auction Catalogue), sale 2133, 13 April 2002, Bolton, No. 244, pp. 38-39.

18 This astrolabe has been discussed in several publications: A. J. Turner, *Astrolabes, Astrolabe-related Instruments*, Rockford 1985 (The Time Museum, Catalogue of Collection, Vol. I, Part 1), No. 15, pp. 120-123; Christie's, *Time Measuring Instruments from the Time Museum*, Auction Catalogue, Thursday 14 April 1988, Lot 157, pp. 98-99; Sreeramula Rajeswara Sarma, '*Yantrarāja* for Dāmodara: The Earliest Extant Sanskrit Astrolabe,' to appear in the proceedings of the conference on astronomy and mathematics in ancient India held on 24 April 2009 at the Altaṃr Centre d'Histoire de Sciences et des Techniques, Brussels.

'May the lord of the *gaṇas* (=Gaṇeśa) be victorious. May it be well. In *Saṃvat* 1663, *Śaka* 1528 current, on *pratipadā*, the first lunar day of the dark fortnight (*vadi*) of *Māgha*, on Sunday, at the city of Ahmadabad, during the reign of the Great *Sultān*, the *Badshāh*, the illustrious Salīm Shāh (i.e., Mughal Emperor Jahangir), [this] astrolabe (*yantrarāja*, lit. king of instruments) was caused to be made (*karāvyu*) by the astrologer Caṇḍīdāsa for the purpose of the reading of [his] son Damodara. Let it be auspicious.'

The date translates to 25 December 1606. The sentence begins in Sanskrit, but ends in medieval Gujarati (*caṇḍidāsaiṃ karāvyu* for Sanskrit *caṇḍīdāsena kāritam*). However, such linguistic mixture is not unusual in the popular Sanskrit in medieval Gujarat.

Chaganalāla assisted **Gaṅgāsahāya Śiśuka** (s.v.) in designing a very large astrolabe in 1870.

Jagatārasiṃha, father of **Kalyāṇa** (s.v.) who made an astrolabe for **Puruṣottama** in 1642.

Jayakṛṣṇadāsa, Jośī,designed two astrolabes which were made by Ustāda **Lakṣmīnārāyaṇa** (s.v.) in 1887 and 1902.

Jemaṃgala carved a wooden column dial in vs 1941/AD 1884. Horniman Museum, London, length 1166mm. Inscription in a mixture of Sanskrit and vernacular:

śrīsaṃvat 1941 sāla miti pauṣa śudi 6 roja śubhaṃ Jemaṃgala dvija hastajesti (?) liṣitaṃ

'In the glorious *Saṃvat* year 1941, on the sixth day of the bright half of *Pauṣa* (= Tuesday, 23 December 1884). [Let it be] auspicious. [By] Brahmin Jemaṃgala (*hastajesti* ?) [it] was carved.

Dāmodara, for whom an astrolabe was commissioned by his father **Caṇḍīdāsa** (s.v.) at Ahmedabad in 1605.

Dharm Chand, Joshī, (*fl.* 1854-73) designed several instruments with legends in Sanskrit, Persian/Urdu and English.[19] Two of his instruments carry legends in Sanskrit.

19 On his oeuvre, see Sreeramula Rajeswara Sarma, *Astronomical Instruments in the Rampur Raza Library*, Rampur 2003, pp. 78-84.

(i) Quadrant-cum-Astrolabe, 212 x 615 mm, legends in Sanskrit, inscription in Persian, vs 1911/AD 1854-5, Linden Museum, Stuttgart.[20] On the obverse side, at the top of the plate, there is the signature of the maker in Persian, which reads *taṣnīf joshī dharam chand sambat 1911*, 'The invention [of] Joshī Dharam Chand, Saṃvat 1911.' The year corresponds to AD 1854. The rest of the legends on this instrument are in Sanskrit and in Devanāgarī characters.

(ii) An identical piece came for auction at Skinner in 2002.[21]

Nandarāma caused, in AD 1767, Sanskrit legends to be engraved on an Indo-Persian celestial globe (diameter 254 mm) made by Muḥammad Ṣālih Thatta in AH 1074/AD 1663.[22] Nasser D. Khalili Collection of Islamic Art, London. The Sanskrit inscription engraved near the southern equatorial pole reads (Figure 2):

śuciśuklasya paṃcamyāṃ siddhanāgeṃduvatsare ।
naṃdarāmeṇa golo'yaṃ kṛtaḥ sopaskaro mude ॥ [metre: *Anuṣṭubh*]

'On the fifth day of the bright half of *Āṣāḍha* (*śuci*) in the [*Vikrama*] year [denoted by] the *Siddhas* (=24), elephants (*nāga* = 8) and the moon (*indu* = 1) (i.e.1824), this [celestial] globe was endowed with additional [labels in Sanskrit] by Nandarāma for [his own] pleasure.' The date translates to Wednesday 1 July 1767. Nandarāma (*fl.* 1763-1778), resident of Kāmyakavana in the Braj region, i.e. region around Mathura on the border between Rajasthan and Uttar Pradesh, composed several works on *Jyotiḥśāstra*, including one on instruments with the title *Yantrasāra* (*Śaka* 1693/ AD 1771).[23]

Narinder Singh, *Mahārājā* of Patiala (r.1845-1862), commissioned in 1850 the unique Gurumukhī/Punjābī astrolabe, which was designed by the astronomer **Rishīkesh** (s.v.) and fabricated by the artisan **Rahīm Bakhsh.**

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20 Sreeramula Rajeswara Sarma, 'Indian Astronomical Instruments in German Collections,' *op. cit.*, pp. 29-32.

21 Skinner, *Science & Technology, featuring Mechanical Music* (Auction Catalogue), sale 2133, 13 April 2002, Bolton, No.233, p. 36.

22 The globe is described by Emilie Savage-Smith in: Francis Maddison & Emilie Savage-Smith, *Science, Tools & Magic*, Part I: *Body and Spirit, Mapping the Universe*, Oxford 1997, No. 134, pp. 237-238. The addition of Sanskrit legends is discussed by Sreeramula Rajeswara Sarma, *The Archaic and the Exotic*, op. cit., p. 307; idem, 'Yavana-yantra to Yantrarāja: Reworking of Arabic Astrolabes in India,' presented at XXIII International Congress of History of Science and Technology, Budapest, Tuesday 28 July- Sunday 2, August 2009.

23 Cf. David Pingree, *Census of the Exact Sciences in Sanskrit*, Series A, Volume 3, Philadelphia 1976, pp. 128-130; vol. 5, Philadelphia 1994, p. 157.

Puruṣottama, for whom **Kalyāṇa** (s.v.) made an astrolabe in 1642.

Premajī, Paṃḍyā, s.o. Paṃḍyā **Vīrajī**, for whom Sonī **Morārajī** (s.v.) made two *dhruvabhrama-yantras* in 1815.

Bālādatta (see Hṛṣikeśa).

Bhāramala, ruler of Kutch, during whose reign Sonī **Morārjī** (s.v.) produced two nearly identical *dhruvabhrama-yantras* for Paṇḍyā **Premajī** in 1815.

Bhālūmal (*fl.* 1839-1850). He signs his name variously as Vuhlomalla, Vuhlovarma, Volhomalla, Lālah Balhūmal Lāhūrī. The actual name is probably Bhālūmal. Some twenty instruments of diverse types, inscribed in Arabic/Persian or in Sanskrit, were made by him. He is not an artisan, but a scholar well-versed in both the Islamic and the Sanskrit traditions of instrumentation.[24] The following five instruments carry Sanskrit legends and signatures in *Anuṣṭubh* metre.

(i) Celestial Globe, Sunday 27 January 1839, diameter 140 mm, PC, London. Inscription engraved on the lower half of the Pisces segment, under the tail feathers of the constellation figure *Samudrapakṣī* (i.e. Cetus), in three *Anuṣṭubh* verses:

iṣvaṃkāṣṭendumāne 'bde vikramārkasya bhūbhujaḥ ।
māghe māse site vaiśve ravau vāre śubhe tithau ॥1॥
śrīgaurīśvara-pādābja-sevānirmalacetasā ।
khagolāḍhya-bhagolo 'yaṃ vulhomallena nirmitaḥ ॥2॥
golatrayopapattyarthaṃ viduṣāṃ bodhagocaraḥ ।
śrī-madhusūdana-pādābje vinayena samarppitaḥ ॥3॥

'In the year measured by the arrows (*iśu* = 5), digits (*aṅka* = 9), eight (*aṣṭau* = 8) and the moon (*indu* = 1) (i.e. 1895) of king Vikramārka, on the auspicious thirteenth (*vaiśva*) lunar day in the bright [half] of the month *Māgha*, on Sunday, (= Sunday, 27 January 1839),

'this celestial globe (*bhagola*) endowed with the sphere of the sky (*khagola*) was constructed by Bhālūmal (*vulhomalla*) whose mind is clear owing to [his] devotion to the lotus feet of the glorious Pārvatī and Śiva,

24 Cf. Sreeramula Rajeswara Sarma, 'Indian Astronomical and Time-Measuring Instruments: A Catalogue in Preparation,' *Indian Journal of History of Science*, 29.4 (1994) 507-528, esp. 523 ; reprinted in: idem, *The Archaic and the Exotic, op. cit.*, pp. 19-46, esp. 44; idem, *Astronomical Instruments in the Rampur Raza Library*, Rampur 2003, p. 10.

'for the demonstration of the three types of spheres (*gola-traya-upapatti-arthaṃ*).[25] [This globe, which is] comprehensible to the learned, is dedicated with humility to the lotus feet of the glorious Madhusūdana.'

(ii) *Dhruvabhrama-yantra*, vs 1896/AD 1839, 225 x 179 mm, Butler Library, Columbia University, New York. Inscription engraved above the horizontal slit:

śrībhavānīśvaraṃ dhyātvā dyuniśāṃgāvabodhārthaṃ ।
turyyaṃ dhruvābhidhaṃ yaṃtraṃ volhomallena nirmitaṃ ॥
saṃvat 1896

'Having meditated upon the glorious Pārvatī and Śiva, this *Dhruvabhrama-yantra* (lit. the quadrant instrument designated as *Dhruva*), for the knowledge of the parts of the day and of the night, was constructed by Bhālūmal (*volhomalla*).'

(iii) Horary quadrant engraved in four parts on a circular plate which is shaped like an astrolabe and equipped with an alidade, vs 1896/AD 1839, diameter 88 mm, for latitude 31;58° N (i.e. of Lahore), Victoria &Albert Museum, London. Inscription engraved in the middle of the instrument:

śrīgaurīśakaruṇāpātra-vulhomallena nirmitaṃ ।
tarkāṃkavasucandrābde jyotiḥsattābhidaṃ sphuṭaṃ ॥

'This accurate [instrument] designated as *jyotiḥsattā* (?), was made by Bhālūmal (*vulhomalla*), the receptacle of Śiva's grace, in the [*Vikrama*] year [denoted by] the philosophical systems (tarka[26] = 6), digits (*aṅka* = 9), the *vasus* (= 8) and the moon (*candra* = 1) (i.e. vs 1896 = AD 1839).'

(iv) Horary quadrant engraved in four parts on a circular plate which is equipped with an alidade, vs 1896/AD 1839, diameter 92 mm, for latitude 31;58° N (i.e. of Lahore), National Museum, New Delhi. Inscription engraved in the middle of the instrument:

oṃ gaurīśakaruṇāpātra-vulhomallena nirmitaṃ ।
tarkāṃkavasucandrābde jyotiḥsanrābhidhaṃ sphutaṃ ॥

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25 Three types of spheres are probably the sphere of the sky (*khagola*), the sphere of the asterisms (*bhagola*) and the sphere of the planets (*grahagola*), envisaged in an armillary sphere. Cf. Lalla, *Śiṣyadhīvṛddhida-tantra*, with the commentary of Mallikārjuna Sūri, edited and translated by Bina Chatterji, New Delhi 1981, ch. xv: *Golabandhādhikāra*.

26 Literally 'logic', one of the six traditional philosophical systems.

'Oṃ. This accurate [instrument] designated as *jyotiḥsanrā* (sic!), was made by Bhālūmal (*vulhomalla*), the receptacle of Śiva's grace, in the [*Vikrama*] year [denoted by] the philosophical systems (*tarka* = 6), digits (*aṅka* = 9), the *vasus* (= 8) and the moon (*candra* = 1) (i.e. vs 1896 = AD 1839).'

Nos. (ii) and (iii) are identical instruments though of slightly different sizes. The inscription begins in (iii) with *śrī*, but in (iv) with *oṃ*. More problematic is the name of the instrument *jyotiḥsattā* in (iii) and *jyotiḥsarnā* or *jotiḥsatrā* (iv). The second is clearly an error, but even the first (lit. existence of the luminaries) makes no sense as the name of an instrument.

(v) Horary quadrant, nd, radius 119 mm, Museum of the History of Science, Oxford. Inscription engraved near the apex of the quadrant (Figure 3):

śrīgirijāpatipadaṃ natvā turyyaṃ vināyāsam ।
vulhovarmmakṛtam śrīviduṣāṃ samayāvabodhāya ॥

'Having bowed to the feet of [Śiva] the consort of Pārvatī, this quadrant (*turya*) was made by Bhālūmal (*vulhovarmma*) for the glorious learned men to know the time without effort.'

Makhan Lāl, Lālah, teacher of **Mangāran** (s.v.) who boasts of his being the *śāgird-i raśīd*, i.e. a devout and worthy pupil to whom the teacher had imparted all the secrets of the trade.[27] However, no instruments made by this teacher are extant.

Mangāran of Patna (*fl.* 1859-68). Made three (or more[28]) nearly identical specimens of a sundial, imitating some European model, possibly of French origin. It is an equinoctial sundial which can be adjusted to the local latitude. A magnetic compass attached to the instrument allows the instrument to be placed on a north-south axis. The scales are marked with the so-called Arabic or English numerals, to measure time in hours of 60 minutes and *ghaṭīs* of 24 minutes. On one side of the dial, Sanskrit names of the twelve zodiac signs are written in Devanāgarī script. The maker's inscription is in Persian language and script, stating that the instrument was manufactured at Patna by Mangāran who was a worthy pupil (*shāgird-i rashīd*) of Lālah **Makhan Lāl** (s.v).

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27 Muhammad Mustāfā Khān 'Maddāh', *Urdū-Hindī Śabdakośa*, 6th edition, Lucknow 1989, s.v.

28 A dealer in Lucknow told me in 2001 that he had acquired a dozen such pieces and disposed off all but one.

(i) Khuda Bakhsh Oriental Public Library, Patna, AH 1275 / AD 1859.[29]

(ii) Victoria & Albert Museum, London, AH 1284/AD 1868.

(iii) Sotheby's, London (Auction 24 October 2007), AH 1295/AD 1878.[30]

Maṇirāma commissioned in 1644 an astrolabe with a diameter of 128 mm, which is now at the Royal Scottish Museum, Edinburgh.[31] Inscription on the front side of the crown:

saṃvat 1700 caitrakṛṣṇaikādaśyāṃ maṇirāmeṇa kāritam.
līlānātha-jyotirvido 'yaṃ

'In *Saṃvat* 1700 on the eleventh day of the dark half of *Caitra* (=2 April 1644), [it] was caused to be made by Maṇirāma.' A later owner **Līlānātha** (s.v.) got his name engraved in a new line: 'This [instrument is] of Līlānātha *Jyotirvid.*'

Mannālāla, officer (*dārogah*) in charge of justice (*dārogya-dharmadhvajaḥ*) at the court of *Sawai* Ram Singh (1835-1880) of Jaipur, caused a beautiful astrolabe to be made by **Śyudatta** (= Śivadatta) for the latitude of 27°N, which is that of Jaipur. Science Museum, London, diameter 344.5 mm. The inscription, silver inlaid on brass inside the shadow squares, reads thus in *Śārdūlavikrīḍita* metre:

śrīkūrmānvayi-rāmasiṃha-nṛpater dārogya-dharmadhvajo
mannālālabudhaḥ prasiddhanagare nāmnā jaye 'kārayat ।
śrīsomeśvara īśa-netra-nidhi-tānāgendranābde site
śrāvaṇye 'kṣitithau śyudattaracitaṃ ca tad bhrājatām ॥

'The learned Mannālāla, the Dārogah and the banner of justice of King Rāmasiṃha of the Kūrma (i.e. Kachchwaha) dynasty, caused this [astrolabe] to be made in the famous town by name Jaya (i.e. Jaipur). May this [instrument], which was made by Śyudatta (= Śivadatta), on the second (*akṣi* = 2) lunar day of the bright half of *Śrāvaṇa* month, in the year ...., flourish!'

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29 Sreeramula Rajeswara Sarma, 'Some Indo-Persian Astronomical Instruments of the early Nineteenth Century,' *Khuda Bakhsh Library Journal*, No. 123 (April 2001) 1-16.

30 Sotheby's, *Arts of the Islamic World, including Fine Carpets and Textiles*, Auction Catalogue, London, 24 October 2007, no. 200, p. 187.

31 Sreeramula Rajeswara Sarma, '*Yantrarāja* at Edinburgh: On the Sanskrit Astrolabe made for Maṇirāma in AD 1644' to appear in S. R. Sarma & Gyula Wojtilla (ed), *Scientific Literature in Sanskrit* (Proceedings of the 13th World Sanskrit Conference, Section 8), Motilal Banarsidass, Delhi 2010 (?).

The year is difficult to decipher. For a four-digit number, there are too many word numerals in the third line. The expression *Someśvara,* in nominative, vocative or locative case, is clearly not a part of the compound. Leaving this expression aside, *īśa* = 11, *netra* 2, *nidhi* = 9, or *īśa-netra* 3, *nidhi* = 9. The last expression is complicated: either it is *tāna-aga-indra-na-abde* where *tāna* = 49, *aga* = 7 and *indra* = 14, but *na* makes no sense, or it is *tā-nāgendra-na-abde* where *nāgendra* is 8, but *tā* and *na* make no sense. The auction catalogue of Ader Picard Tajar[32] states that the astrolabe is dated AD 1842, which should correspond to vs 1899 and *Śaka* 1764. It is impossible to derive either number from the Sanskrit text! But the catalogue did not even decipher the name Mannālāla correctly.

Mādhavasiṃha (popularly known as Sawai Madho Singh), son of Sawai Jai Singh, ruled Jaipur state from 1750 to 1767. Two instruments bear his name. These two items are in burnished brass and the lines, numbers and inscriptions are filled with black and red enamel. A third one, in wood, does not carry his name but is attributable to him on stylistic and other grounds. All the three instruments are preserved in the stores of the Jaipur Observatory. A cloth instrument designed by him is in the Sawai Mansingh II Museum, City Palace, Jaipur.[33] Thus, he seems to have continued his father's interest in astronomical instruments, but on a miniature scale. The inscriptions on the four instruments are as follows:

(i) A set of three square column dials (50 x 50 x 455; 50 x 50 x 455; 42 x 42 x 420 mm) called *soṭā-yantras.* All the three bear an identical inscription in *Anuṣṭubh* metre:

prakāśaṃ mādhavavyāghrabuddher niṣpakṣapātataḥ ।
paśyānāyāsataḥ sūkṣmaṃ svaprakāśaḥ prakāśitaḥ ॥

'Look dispassionately at the brilliance of the intellect of Mādhava the Tiger/ Mādhava with the Tiger's intellect. Without much effort, he made his brilliance manifest minutely.'

(ii) Horary quadrant with separate scales for each 3° of solar longitude arranged in eight parts on the two sides of a circular plate (diameter 345 mm) which is shaped like an astrolabe and equipped with an alidade. While the astrolabe is called *yantrarāja* ('king

32 Ader Picard Tajan, Paris, *Instruments scientifiques anciens,* auction catalogue, 23 March 1983, No. 47, p. 26.

33 David Pingree, *A Descriptive Catalogue of the Sanskrit Astronomical Manuscripts Preserved at the Maharaja Man Singh II Museum in Jaipur, India,* Philadelphia 2003, No. 221, pp. 107-109.

of instruments') in Sanskrit, this one bears a grander designation *Yantrādhipati* ('overlord of instruments') which is engraved on the crown. Inscription at the centre of the plate in four *Anuṣṭubh* verses:

śrīman-mādhavasiṃhasya paśyemāṃ yantranirmitiṃ ।
paśyan prajñāti mūrkho 'pi tatkālaṃ kālavid bhavet ॥
jīyāc ciram ayaṃ yasya vāgvilāsaṃ pramādataḥ ।
śrutvā mandaḥ kīdṛśo 'pi sadyo 'sau kṛtimān bhavet ॥
yaḥ (yat?) kṛpākṣanimeṣeṇa durbhāgyo yasya lakṣitaḥ ।
tatkṛpādṛṣṭikaṇikāṃ vāñchanti bhāgyaśālinaḥ ॥
sa jayaty asya kopāgnir yallavaḥ svavirodhinaṃ ।
dṛptaṃ dahati saṃvṛddhasamudrajalam aurvavat ॥

'Behold the design (*nirmiti*) of this instrument of the glorious Mādhavasiṃha! Looking at this, even a fool will understand [time] and become at once a knower of time.

'May he live long! After listening to the flourishes of his speech [even] by chance (*pramādataḥ,* lit. by mistake). one would become— howsoever dullard one might be— at once an accomplished person.

'By the flutter of whose compassionate eyes, the misfortune of whosoever is seen [will be dispelled]; fortunate ones desire a fraction of his compassionate glance. (Difficult syntax; it probably means: a glance of his compassionate eyes dispels the misfortune of anybody on whomsoever it falls; therefore fortunate people desire even a fraction of that glance to fall on themselves).

'Victorious is that fire of his anger, a spark from which burns down his arrogant enemy, just as the marine fire burns down the abundant waters of the ocean.'

(iii) Wooden folding sundial, also called *soṭā-yantra,* which is attributable to him, carries this inscription.

yad viparīte 'py anukūlaṃ kṛte 'pi
yadvat karma nareśasya bhavati ।
tathā viparīte kṛte 'pi yantre
phalam apy anukūlam ॥ [metre irregular]

'Just as the king's action, though adverse, turns out to be favourable, even so, when this instrument is held upside down, the result (reading) will be correct.'

(iv) Star chart painted on starched cloth, 765 x 735 mm. A red silk thread with a red and green silk tassel is attached to the centre of the chart and functions as an index to show for any given moment the risings, culminations and settings of several *nakṣatras* and other astrolabe stars. Inscription painted in the middle of the chart:

jayati yaṃtram idam jhaṭiti sphuṭaṃ
diśati darśanato 'sya niśāgataṃ ।
tanunṛpāspadapatnisukhānvitaṃ
nṛpati-mādhavasiṃhavinirmitaṃ 1 ॥ [metre: *Drutavilambita*]

'May this chart (*yantra,* lit. instrument) designed by King Mādhavasiṃha be victorious. Just by looking at it, it shows instantly and clearly the nocturnal ... (?).' The third line which literally means 'endowed with the happiness of the wife, the abode of the slender king' makes absolutely no sense in this context.

Madho Singh is said to be an accomplished poet who compiled an anthology of Sanskrit poems and rendered them into Brajabhāṣā.[34] But the present attempts at versification do not betray his poetic talents.

Murārajī Kuarajī, Ṭhākura, made an astrolabe at Varanasi in vs 1695/AD 1638, which was owned by Josī **Haranātha**. Bhandarkar Oriental Research Institute, Pune, diameter 158 mm. The inscription in Sanskrit mixed with medieval Gujarātī, engraved on the rim of the astrolabe, reads as follows:

śrīsaṃvat 1695 varṣe mārgasiravadi 13 śukre vārāṇāsīmāṃ ṭhākura murārajī kuarajī vaiśaṇau kīḍho jaṃtrarāja pātaśāha śrīśāhajāhā vijayarājye sana ।।1।।śrī।।

'In the glorious Saṃvat year 1695, on Friday, the thirteenth day of the dark half of *Mārgasira*, in the [regnal] year (*sana* from the Arabic *san*) eleven in the victorious kingdom of the emperor (*pātaśāha*), the glorius Shāh Jahān (= Friday, 3 December 1638), *Ṭhākura* Murārajī Kuarajī *Vaiṣṇava* made (*kīḍho*) this astrolabe (*jantrarāja*) in Varanasi.'

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34 Gopal Narayan Bahura, *Literary Heritage of the Rulers of Amber and Jaipur, with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (1. Khasmohor Collection),* Maharaja Sawai Man Singh II Museum, City Palace, Jaipur 1976, pp. 75-77.

An inscription on the front side of the crown proclaims the ownership thus:

josī haranātha vāṃchaḍā buhurānapurīṇo yaṃtrarāja.

'The astrolabe (*yaṃtrarāja*) is of (belongs to) Josī Haranātha Vāṃchaḍā of Burhanpur.'

It is indeed remarkable that an artisan by name *Ṭhākura* Murārajī Kuarajī *Vaiṣṇava* makes an astrolabe in Varanasi for an astrologer Haranātha Vāṃchaḍā, who belongs to Burhanpur in Central India, and engraves on it two inscriptions regarding the owner and the maker, mainly in Sanskrit language, but with the operative verb (*kīḍho*) and a genitive particle (*no*) in Gujarati!

Motilāla made a unique but incomplete *dhruvabhrama-yantra* in wood and ivory (240 x 276 x 9 mm), the lines and legends on which were produced by inlaid silver wire, in *Śaka* 1707/AD 1785 for King **Kīrticandra**. PC, Brussels. The inscription along the arc of the quadrant on the reverse side, in *Indravajrā* metre, reads thus:

munyabhravāraikamite śakābde
śrī-kīrticaṃdrasya nṛpādhipasya ।
ājñānusārād akarot suyaṃtraṃ
śrī-motilālābhidha-śilpisiṃhaḥ ॥

'In the *Śaka* year measured by the sages (*muni* = 7), sky (*abhra* = 0), weekdays (*vāra* = 7) and one (i.e. *Śaka* 1707 = AD 1785), following the orders of the lord of the kings, the glorious Kīrticandra, the lion among the artisans (*śilpisiṃha*), the glorious Motilāla, made this excellent instrument.'

This is the earliest extant specimen of the *dhruvabhrama-yantra* which, due to an unfortunate error in the placement of zodiac signs on the dial, was left incomplete. Kīrticandra was apparently the ruler of some kingdom in Rajasthan around 1785 but it has not been possible to identify him.

Morārajī, Sonī, of Bhuj, Saurashtra, Gujarat, crafted two nearly identical *dhruvabhrama-yantras* for Paṇḍyā Premajī, son of Paṇḍyā Vīrajī, in 1815 during the reign of Bhāramala.

These two instruments were auctioned in Paris in 1980.[35] One (161 x 121 mm) was acquired by the Paris Observatory and the other (165 x 120 mm) by the Museum of the History of Science, Oxford.[36] The inscription on the obverse:

adye śrībhujanagaramadhye mahārājya-rāu-śrī-bhāramalajī-vijayarājye śrī paṇḍyā vīrajī tasyātmaja paṇḍyā premajīkasya idaṃ dhruvajaṃtraṃ kra(sic! read *kṛ*)*taṃ sonī morārajī.*

'Today, in the city of Bhuj, during the victorious reign of Mahārāja Rāu Śrī Bhāramalajī, this *dhruvabhrama-yantra* of Paṇḍyā Premajī, son of Śrī Paṇḍyā Vīrajī, was made [by] Sonī Morarajī.'

Reverse:

śrīmana rājā vikramārkarājye saṃvat 1872 varṣe
śālīvāhanaśāke 1738 pravartamāne jyeṣṭha va-
di 11 śukre tad[d]ine sāyano ravi 3/0/0/0/ akṣa
bhā 5/0 akṣakarṇa 13 daṃkṣākrāti (sic!) *22/30 sadaiva*
kacha saurāṣṭra yaṃtram idam ||

'In the *Saṃvat* year 1872 of the reign of the glorious king Vikramārka, the current year 1738 of *Śālivāhana* era, on Friday, the eleventh day of the dark half of *Jyaiṣṭha* (= 2 June 1815). On this day the Sun's tropical longitude (*sāyano raviḥ*) is 3/0/0/0; equinoctial shadow (*akṣabhā*) 5/10; equinoctial hypotenuse (*akṣakarṇa*) 13; latitude (*daṃkṣākrāti* !) 22;30. This instrument should be employed always in Kacch, Saurashtra.' The correct latitude is 23;15° N; longitude 69;49° E. Instead of *akṣāṃśa,* the inscription employs *daṃkṣākrāti* for latitude, which makes no sense and is clearly an error.

Yādo Josi of Ukala-*grāma* owned or made a *dhruvabhrama-yantra*, now at the Raja Dinkar Kelkar Museum, Pune, 104 x 112 mm. Inscription engraved on the reverse side containing the quadrant: *ukalagrāmasthita yādo josi,* 'Yado Josi resident of Ukala village.'

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35 Leonard Linton, *Collection Leonard Linton et de divers amateurs,* Catalogue of Auction at Paris on 9-10 October 1980, Paris 1980, Nos. 229 and 230, pp. 183-184.

36 Cf. R. G. W. Anderson, *Science in India: A Festival of India Exhibition at the Science Museum, London, 24 March – 1 August 1982. Catalogue*, Science Museum, London 1982, No. 132, p. 36; Jean-Pierre Verdet, 'A propos de deux petits quadrants indiens' in: W. D. Hackmann & A. J. Turner (ed), *Learning, Language and Invention: Essays presented to Francis Maddison*, Aldershot-Paris 1994, pp. 309-321.

Raṇakuṃjalāla made or owned a Sanskrit astrolabe (diameter 213 mm), now in a PC in Germany. It is an undated astrolabe made with a single plate for the latitude of 26°, roughly that of Jodhpur. On the crown is engraved: *oṃ oṃ raṇakuṃjalāla.*[37]

Rahīm Bakhsh, the artisan (*kārīgara*) who fabricated the unique Gurumukhī /Punjabi astrolabe, designed by *Jotisī* **Rishīkesh** (s.v.) in 1850, for Mahārājā **Narindar Singh** of Patiala.

Rāghavajit, *Jyo[tirvid]*, son of **Daivajña Viśvanātha**, of Surat (Sūryapura), owner of an astrolabe made in 1669. Rāghavajit also copied in 1668 Mahendra Sūri's *Yantrarāja* on the astrolabe. In the early twentieth century, the astrolabe and the manuscript were owned by R. K. Raikva of Surat, who published the illustrations of the astrolabe in his edition of Mahendra Sūri's *Yantrarāja.*[38] Subsequently, the astrolabe seems to have been offered for sale. Photographs in the archives of the Museum of the History of Science, Oxford. Inscription on the back of the crown:

śā 1591 pra[thama]
ā[ṣāḍha] śu. 7 bhṛgau kṛtaḥ
daivajña śrī viśvanātha-suta
jyo. rāghavajito yaṃtrarājaḥ

'Made on *Śaka* 1591 first *Āṣāḍha*, bright half, seventh day, Friday (= 5 July 1669), this astrolabe is of (belongs to) *Jyo[tirvid]* Rāghavajit, son of *Daivajña* Viśvanātha.'

Rāmacandra, Jośī, made, at the instance of Rao Bahadur **Keśarīsiṃha** (s.v.), the ruler of Kuchaman, a crude imitation of the European diptych dial in wood (220 x 135 x 20 mm) and incorporated a *phalaka-yantra* and a *dhruvabhrama-yantra* on the outer surfaces of the two plates. The instrument is not well preserved and the inscriptions on it are partly obliterated. On the inner surface of the lower plate is partly visible *sa[ṃ]vat 1941 phā[lguna]* (February/March) 1885) which must be the time of manufacture. On the inner

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37 Described and illustrated in Sreeramula Rajeswara Sarma, 'Indian Astronomical Instruments in German collections,' *op. cit.*

38 Kṛṣṇaśaṅkara Keśavarāma Raikva (ed), *Yantrarāja of Mahendra Sūri, together with the commentary of Malayendu Sūri and Yantraśiromaṇi of Viśrāma,* Bombay 1936.

surface of the upper plate can be seen *rāvabhādurajī Śrī (?) 108 śrī keśarī siṃhajī karājemaṇ josī rāmacaṇdraṃ,* "Rao Bahadur the glorious Keśarīsiṃja-jī caused it to be made (?) [by] Jośī Rāmacandra." The same person appears to have made another diptych (17 x 11 x 2 cm) dial which carries no date or name but strongly resembles the former in style and workmanship. On the outer surfaces of this diptych dial are incorporated a *dhruvabhrama-yantra* and a sine quadrant. [39]

Rāmanātha, *Jyotirvid,* made a *dhruvabhrama-yantra* (272 x 232 mm) in vs 1884/ AD 1827 at Kota in the reign of **Kiśorasiṃha** (s.v.) who ruled from 1819 to 1827. Science Museum, London. Inscription engraved above the horizontal slit at the top and continued on both sides of the slit (Figure 4):

śrīgurave namaḥ ।
śrīmat kiśorasiṃhasya rājye yaṃtram idaṃ kṛtaṃ ।
jyotirvid-rāmanāthena koṭākhye nagare vare ।।1।। [metre: *Anuṣṭubh*]
saṃvat 1884 pauṣe māse śukle pakṣe 2 guruvāsare ।। *śrīḥ* ।।

'Salutation to the glorious preceptor. This instrument was made in the kingdom of the glorious Kiśorasiṃha by *Jyotirvid* Rāmanātha in the excellent city by the name of Kota, in *Saṃvat* 1884, on Thursday, the second [day] of the bright half of *Pauṣa* month (= 20 December 1827). Glory.'

Rāmapratāpa, artisan (*śilpin*), made an astrolabe which was designed by **Gaṅgāsahāya** (S.V.) in 1795.

Rāmayatna Ojhā, owner of a unique astrolabe (diameter 202 mm) with *Kaṣapayādi* notation, now at the Varanasi Sanskrit University. His name is engraved on the obverse side of the crown.[40]

Rāmasiṃha, ruler of Kota from 1827 to 1866, who was patron for an astrolabe made by the son of **Vaijanātha** (s.v.) in 1834.

Rishīkesa, *Jotiṣī*, who in 1850 designed an astrolabe with a diameter of 195 mm, which was made by the artisan **Rahīm Bakhsh**, on the order of Mahārājā **Narinder Singh** of Patiala (r.1845-1862).[41] The labels are in Gurumukhī script and Punjabi language.

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39 The two instruments are now with Tesseract, Early Scientific Instruments, Hastings-on-Hudson, NY, USA.

40 Cf. Sreeramula Rajeswara Sarma, 'Kaṣapayādi Notation on a Sanskrit Astrolabe,' *Indian Journal of History of Science,* 34 (1999) 273-287; reprinted in: idem, *The Archaic and the Exotic, op. cit.*, pp. 257-272.

41 Described and illustrated by Sreeramula Rajeswara Sarma, 'Indian Astronomical Instruments in German Collections,' *op.cit.* 257-272.

Until recently the astrolabe was in a private collection in Germany. PLU. The inscription engraved inside the shadow squares and continued below them:

śrī mahārāje rājagāna mahārā-
jedhirāja rājeśvara mahārāje nareṇdrasiṇgha ma-
hīmdra bahīdra jī ke huha(sic! read *ka*)*m so yahu jaṇtrarāj ba-*
ṇāyā ॥ sarkār paṭiyāle kī mo ॥ saṃbat
1907 caitra sudī 1 brahasapatibār.
banāūṇe vāle jotasī sī Rikhīkes
kārīgar Rahīm Bakhas

'This astrolabe was made on the order of Mahārājā Rājagāna Mahārājedhirāja-rājeśvara-mahārāja Narendra Siṃha Mahīndra Bahādur, under the seal (*mo[har]*) of the Government of Patiala, on *Saṃvat* 1907 *Caitra sudi* 1 Thursday (=Thursday 14 March 1850). The person who got it made (i.e. who designed) is *Jotishī Śrī* Rishīkesh, and the person who made it (*kārīgar*) is Rahīm Bakhsh.'

Lakṣmīnārāyaṇa, master artisan (*ustāda*), of Kuchaman in Rajasthan, constructed four astrolabes in 1883, 1887, 1902 and 1903 respectively. The last two are the very last traditional astrolabes made in the twentieth century. Interestingly there is a close resemblance in the text of the inscriptions on (i) and (iv) on the one hand and (ii) and (iii) on the other. Also (ii) and (iii) were designed by **Jayakṛṣṇadāsa**, while (i) and (iv) were designed by his son **Haridatta**. In all the four cases, *kṛtaṃ* was used in the sense of 'designing'.

(i) Astrolabe with four plates, diameter 333 mm, formerly in the private collection of Leonard Linton,[42] now probably in Ar-Riyadh. The inscription within the shadow squares at the back reads:

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42 Leonard Linton, *Collection Leonard Linton et de divers amateurs, op. cit.*, No. 183, pp. 126-127. The catalogue is excellently produced, but the person who was consulted on Sanskrit instruments, had insufficient grasp of the language and translated the inscriptions with ludicrous results. The front of the astrolabe is illustrated on p. 127. On p. 126 the inscription is reproduced and translated, quite erroneously, thus: 'In the kingdom of Śrī Keśarīsiṃhajī [of the] great kingdom of Rābabahāṣṇarjī, this instrument resembling the moon [was] made by Haridatta, son of astronomer Jayakṛṣṇa, [forged named] Lakṣmīnārāyaṇa.' *Saumya-yantra* is the technical term for the northern astrolabe and not an 'instrument resembling the moon'! The description concludes with this erudite remark: 'The maker of the astrolabe was presumably named after the astronomer Haridatta who, according to a tradition in Kerala (southern India), was the author in A.D. 684 of an astronomical treatise, *Grahacāranibandhana*.' Surely thousands of persons must have borne the name of Haridatta during the twelve hundred years between 684 and 1883 and in the vast stretch of land between Kerala and Kūcamaṇa!

mahārājya (sic! read *rāja*) *śrī-keśarīsiṃhajī rājye saimya* (sic! read *saumya*)*yantram idaṃ śrījyotirvij-jayakṛṣṇātmaja-haridatta-kṛtaṃ ustā[da] lakṣmīnārāyaṇa saṃbat 1940 śake 1805 miti śrāvaṇa-kṛṣṇa-daśamyāṃ 10 ravau* ॥

॥ *kūcamaṇamadhye* ॥

'In the kingdom of (Rāo Bahādur-jī, a British colonial title that was scratched out in favour of a grander title 'Mahārāja' which was, however, spelt incorrectly as 'Mahārājya') *Mahārāja Śrī* Keśarīsiṃha, this northern astrolabe (*saumyaṃ yantram,* lit. northern instrument) was designed (*kṛtaṃ*) by Haridatta, son of the astronomer Jayakṛṣṇa, [and was made by] the master artisan (*ustāda*) Lakṣmīnārāyaṇa. *Saṃvat* 1940, Śaka 1805, Sunday, the tenth day of the dark half of the month of *Śrāvaṇa* (= Sunday, 29 July 1883). In [the city of] Kuchaman.'

(ii) Astrolabe with a single plate to serve 27° (Kuchaman, Jaipur, Agra etc.), d. 220 mm, vs 1944/AD 1887, Sanjay Sharma Memorial Museum and Research Institute, Jaipur. Within the shadow squares and below, it is engraved the maker's signature which runs thus:

josī jayakṛṣṇadāsajī kṛtaṃ.

uratā (sic! read: *ustā*[*da*]) *lakṣmīnārāyaṇena yu* (sic! read: *su*) *saṃpāditaṃ.*

paṃ. jyotirvid audīcya mahādevastanu (sic! read: °*sūnu*)

acaleśvarakasya yaṃtrarāja.

kucāmaṇi.

'Designed by the astrologer Jayakṛṣṇadāsa-jī, well executed by the master artisan Lakṣmīnārāyaṇa, this *yantrarāja* belongs to Acaleśvara, son of the *Audīcya* Brahmin, *Pandita Jyotirvid* Mahādeva. [The astrolabe was made in the city of] Kuchaman.' On the left of the shadow box is written *Saṃ. 1944*, which corresponds to AD 1887.

(iii) Astrolabe with a single plate to serve 27°, d. 219 mm. It carries the year [vs] 1959 = AD 1902. PC, Paris. The inscription reads thus:

jośī jayakṛṣṇadāsajī kṛtaṃ

ustāda lakṣmīnārayaṇena susaṃpāditaṃ ।

paṃ. jyotirvida audīcya mahādevasūnu-acaleśvara

kasya yaṇtrarāja

kūcamaṇi

'Designed by the astrologer Jayakṛṣṇadāsa-jī, well executed by the master artisan Lakṣmīnārāyaṇa, this astrolabe belongs to Acaleśvara, son of the *Audīcya* Brahmin, Pandit, *Jyotirvid* Mahādeva. [The astrolabe was made in the city of] Kuchaman.'

(iv) Astrolabe, single plate to serve 27°, diameter 244 mm, vs 1960/AD 1903, Skinner (Auction 13 April 2002):[43]

> *rāvabahādura-mahārāja-śrī-serasiṃhajī-rājye jyotirvij[j]ayakṛṣṇātmaja-haridatta-kṛtaṃ saṃ 1960 | kārtika śukrā* (sic! read *śukla*) *6 cāndravāsare ustā[da] Lakṣmīnārāyaṇa kucāmaṇamadhye* ||

'In the kingdom of Rao Bahadur *Mahārāja* the glorious Serasinha (Sher Singh), this astrolabe was designed by Haridatta, son of astronomer Jayakṛṣṇa, [and was made] by the master artisan Lakṣmīnārāyaṇa. *Saṃvat* 1960, Monday, the sixth day of the bright half of *Kārtika* (= Monday 26 October 1903) in Kuchaman (*Kucāmaṇa*).'

Līlānātha ***Jyotirvid*** owned, at a later point, the astrolabe which was commissioned by **Maṇirāma** (s.v.) in 1644 and which is now at the Royal Scottish Museum, Edinburgh. After acquiring it, Līlānātha got the following inscription engraved below Maṇirāma's inscription: *līlānāthajyotirvido 'yam,* 'This [astrolabe is] of Līlānātha *Jyotirvid.*'

Viśvanātha, *Daivajña*, father of *Jyotirvid* **Rāghavajit** (s.v.), for whom an astrolabe was made in 1669.

Vīrajī, Paṇḍyā, father of Paṇḍyā **Premajī,** for whom two *dhruvabhrama-yantras* were made by Sonī **Morārajī** (s.v) in 1815.

Vaijanātha's son (probably designed and) engraved (*aṅkita*) a silver universal (*nikhila-viṣaya-yogya*) quadrant called *yantra-cintāmaṇi* ('wishing-gem of an instrument') at Kota, in Rajasthan, at the instruction of the ruler **Rāmasiṃha** (s.v.), who presented it to the Government of India.[44] PLU.

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43 Skinner, *Science & Technology, featuring Mechanical Music* (Auction Catalogue), sale 2133, 13 April 2002, Bolton, no. 239, p. 37: 'Major K. D. Erskine, *Imperial Gazetteer of India,* Provincial Series, Rajputana, Calcutta 1908, p. 198, states that the then Ṭhākura of Kuchaman, Sher Singh, was a member of the State Council and Rao Bahadur; this confirms his title in the inscription.'

44 Cf. J. J. Middleton, 'Description of an Astronomical Instrument presented by Raja Ram Singh of Kota, to the Government of India,' *Journal of the Asiatic Society,* Calcutta, NS 32 (1830) 831-838.

saṃvat 1891 śake 1756 Āṣāḍha śukla 7 ravivāre ||
jayati jagati koṭādhīśvaro rāmasiṃhaḥ
paraguṇagaṇabhājā tena saṃcoditena |
nikhilaviṣayayogyaṃ vaijanāthasya jenā (sic! read: *thātmajenā*)
*ṅkitam idam iha yaṇtraṃ yantracintāmaṇistham ||/|| [metre: *Mālinī*]*

'On Sunday, vs 1891, *Śaka* 1756,*Āṣāḍha śukla* 7(= 13 July 1834). Victorious in this world is Rāmasiṃha, the lord of Kota! Instructed by him, who appreciates the virtues in others, Vaijanātha's son made (*aṅkita*) this instrument called *Yantracintāmaṇi*, which can be used at all latitudes.'

Śivadatta (see Śyudatta).

Śivalāla, the artisan (*śilpin*), made a large astrolabe which was designed by **Gaṅgāsahāya Śiśuka** (s.v.) in 1870.

Śyudatta (=Śivadatta) made an astrolabe for **Mannālāla** (s.v.) at Jaipur.

Sakhārama Jośī, according to Shankar Balakrishna Dikshit,[45] made the following instruments between the years 1790 and 1796 : (i) astrolabe for the latitude of Saptarṣi (Satāra) at 17.42° in *Śaka* 1718/1796 A.D. with 27 stars positions marked on the rate, (ii) astrolabe for the latitude of Karavīra (Kadalī) at 17.21°, (iii) quardrant, (iv) *phalaka-yantra* and (v) *dhruvabhrama-yantra*. These were with the great-grand son of Sakhārāma Jośī at Kadeguddi, near Belgaum, Sahapur Taluka, in 1896.

Salīma-sāha (Salīm Shāh), Mughal Emperor Jahangir, during whose reign **Caṇḍīdāsa** (s.v) got an astrolabe made for his son **Dāmodara**.

Sāha-jahā, Shāh Jahān, Mughal Emperor, in whose 11th regnal year **Murārajī** (s.v.) made an astrolabe at Varanasi.

Sūryamalla, architect (*sūtradhāra*), made a single plate astrolabe, with a diameter of 270 mm. It is stated that the astrolabe was meant to serve the latitude 28:16°, possibly that of Delhi, although its traditional value is 28;39°. The astrolabe was on sale at the Libraire Alain Brieux, Paris, in 1994.[46] PLU. Inscription under the shadow squares

45 Shankar Balakrishna Dikhit, *History of Indian Astronomy*, English translation of his Bhartiya Jtotis-Śāstra, by R.V. Vaidya, Delhi 1981, Part III, p. 233 n.

46 Catalogue September 1994,

akṣāṃśā[ḥ] 28\16 akṣabhā 6\30

idaṃ yantraṃ kastaracandrasyopadeśena sūtradhāra-sūryamallena kṛta[m] \|\|\|\|

'Latitude 28;16° Equinoctial shadow 6\30

'This instrument was made by the architect (*sūtradhāra*) Sūryamalla according to the instructions of Kastaracandra (sic! **Kastūrīcandra**).'

Scrasiṇha (Sher Singh), Rao Bahadur, ruler of Kuchaman, during whose reign the master artisan Lakṣmīnārāyaṇa (s.v.) produced an astrolabe in 1903.

Haranātha, Josī, of Burhanpur, who probably owned the astrolabe, which was made by **Ṭhākura Murārajī** Kuarajī (s.v.) at Varanasi in vs 1695/AD 1638. The inscription on the back of the crown proclaims his ownership thus:

josī haranātha vāṃchaḍā buhurānapurīṇo yantrarāja.

'This astrolabe belongs to Josī Haranātha Vāṃchaḍā of Burhanpur.'

Haridatta, s.o. *Jyotirvid* **Jayakṛṣṇa**, designed two astrolabes which were executed by Ustāda **Lakṣmīnārāyaṇa** (s.v.) in vs 1940/AD 1883 and vs 1960/AD 1903 respectively.

Hṛṣīkeśa, *Jyotirvid*, of Kūrmācala (Kumaun). His name is engraved on a reworked Arabic astrolabe with a diameter of 123 mm, originally made by Wafā' ibn Munajjim in AH 1017/AD 1608. The limb of this astrolabe was ground and a scale with Devanāgarī numerals was engraved on it. At the back a shadow square was added with Sanskrit labels and Devanāgarī numerals. Additions in Sanskrit were also made on some of the five plates. Formerly it was in the private collection of Leonard Linton.[47] Now it is said to be in the Museum of Islamic Art at Doha in Qatar. When the astrolabe was reworked with Sanskrit labels, around the lower part of the rim, the following inscription was engraved:

svasti śrī-kūrmmācalīya-hṛṣīkeśa-jyotirvidāṃ śrī-mantrarājo (sic! read *yantrarajo*)*-vino* (?) *vālādattātmajasyārtham* \|\|

47 Leonard Linton, *Collection Leonard Linton et de divers amateurs,* op. cit., No. 179, pp. 121-123. Cf. Sreeramula Rajeswara Sarma, '*Yavana-yantra* to *Yantrarāja*: Reworking of Arabic Astrolabes in India,' *op. cit.*

'Let it be auspicious. Of the astrologer Hṛṣīkeśa of Kūrmācala (Kumaun), the glorious astrolabe (ie. The astrolabe belongs to Hṛṣīkeśa of Kūrmācala) ... for the sake of Bālādatta's son.'

It is likely that Hṛṣīkeśa got this astrolabe reworked. The middle part of the inscription is undecipherable and therefore it is not clear how Hṛṣīkeśa is connected to Bālādatta's son.

Hṛṣīkeśa, *Jyotirvid*, made a *yantracintāmaṇi*, for the sake of **Caṇḍīdatta's son**. Adler Planetarium, Chicago, radius 141 mm.[48] Inscription on the observe side, above and below the centre:

palabhā 7/1 carakhaṃḍāni 70/56/23

śrījyotirvid-dhṛṣīkeśanirmito yantracintāmaṇiḥ śrīcaṇḍīdattātmajasyārtham.

'Equinoctial shadow 7/1. Ascensional differences 70/56/23.

'The *yantracintāmaṇi* was made by the glorious *Jyotirvid* Hṛṣīkeśa for the sake of Caṇḍīdatta's son.

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48 David Pingree, *Eastern Astrolabes*, Adler Planetarium, Chicago 2009, pp. 206-207.

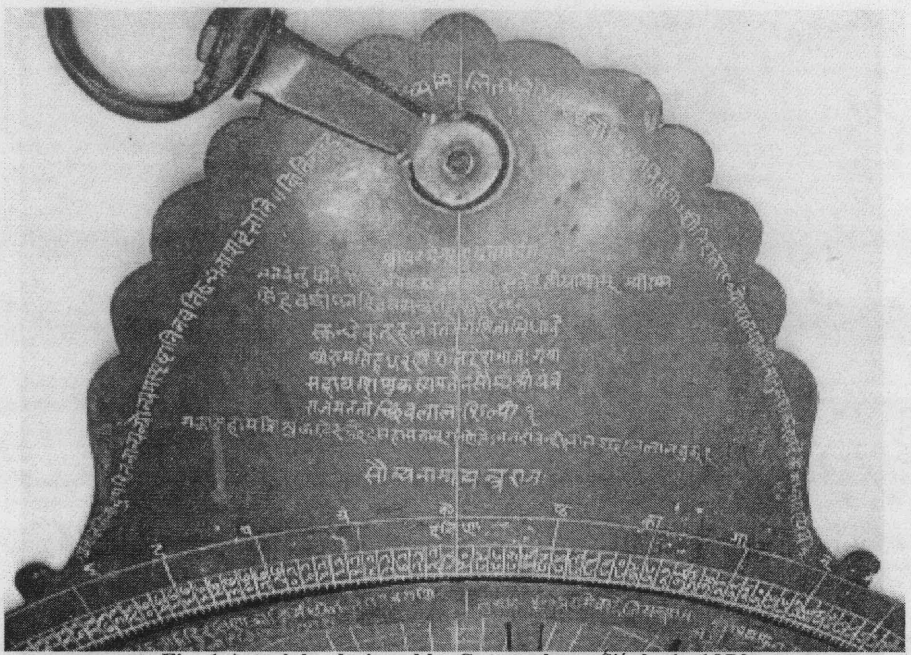

Fig. 1 Astrolabe designed by Gaṅgāsahāya-Śiśuka in 1870
Photo courtesy Science Museum, London

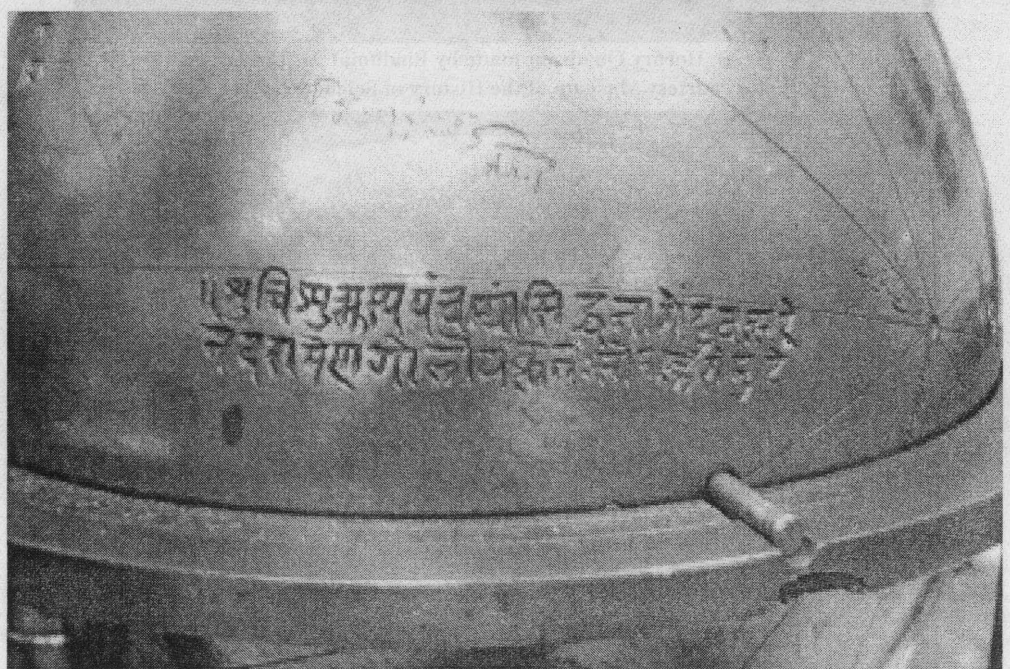

Fig. 2 Celestial Globe reworked in Sanskrit by Nandarāma in 1767
Photo courtesy Nasser D. Khalili Collection of Islamic Art

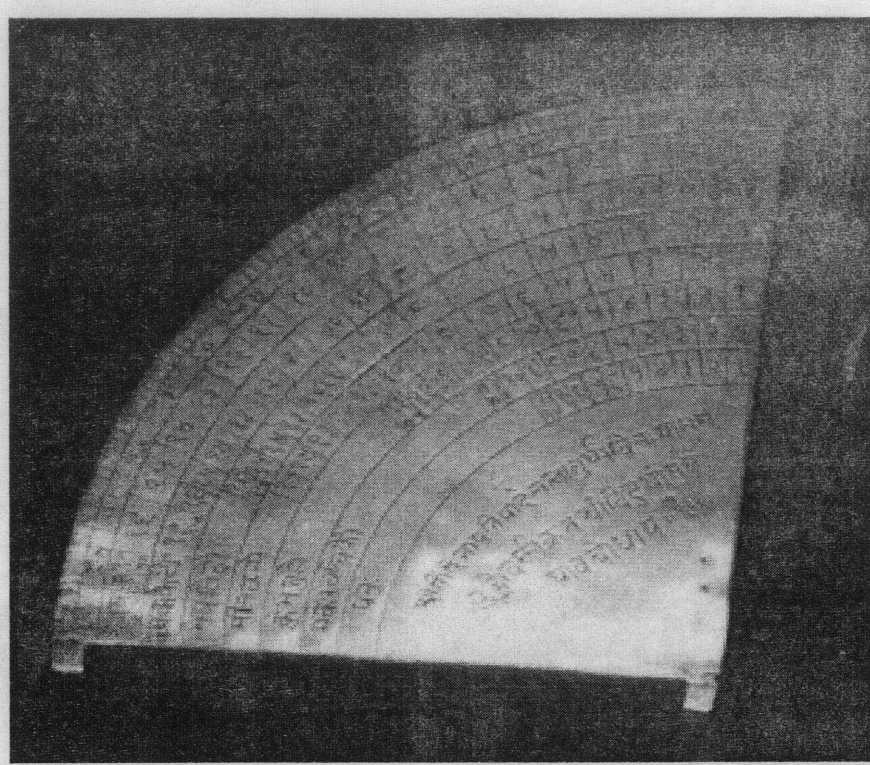

Fig. 3 Horary Quadrant made by Bhālūmal ca. 1850
Photo courtesy Museum of the History of Science, Oxford

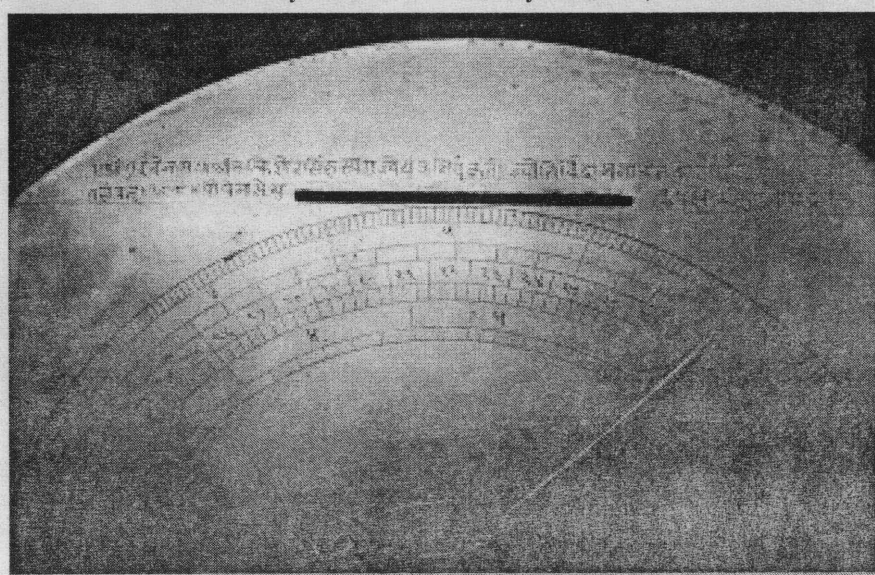

Fig. 4 *Dhruvabhrama-yantra* designed by Rāmanātha in 1827
Photo courtesy Science Museum, London