Setting up the Water Clock for Telling the Time of Marriage

SREERAMULA RAJESWARA SARMA

0.1 From about the fourth century AD up to recent times the water clock of the sinking bowl type (*Ghaṭikā-* or *Ghaṭī-yantra*) has been the chief device in India for measuring time.[1] The instrument consists of a hemispherical bowl (*ghaṭikā* or *ghaṭī*) with a minute perforation at the bottom. When this bowl is placed on the surface of water in a larger vessel or basin (*kuṇḍa, kuṇḍikā, kuṇḍī*), water slowly percolates into the bowl through the perforation. When the bowl is full, it sinks to the bottom of the vessel with a clearly audible thud. The weight of the vessel and the size of the perforation are so regulated that the bowl sinks sixty times in a nychthemeron (*ahorātra*). Thus the time taken for filling the bowl once is one-sixtieth part of a nychthemeron, or twenty-four minutes. This was the standard unit of time measurement in India and is called *ghaṭikā* or *ghaṭī* after the name of the bowl. The *ghaṭikā* is subdivided into sixty *vighaṭikās*, which are also called *palas*.[2]

When the bowl sinks to the bottom of the vessel, indicating the completion of one *ghaṭikā*, this fact is broadcast with blasts on a conch-shell or strokes on a drum. In the early medieval period, the conch and drum were replaced by the gong, which was designated in the Middle Indic as *ghaḍiyāla* (from *ghaṭikālaya*, 'water clock house').

[1] On the different types of water clocks, see Needham, p. 115; on the sinking bowl type in India, see S. R. Sarma, 'The Bowl that sinks and tells Time'.

[2] This sinking bowl type replaced the outflow type which too measured the standard unit of twenty-four minutes. Here the instrument and also the time unit were styled *nālikā, nālī* or *nāḍikā, nāḍī*. Even after the outflow clock was discarded, the old names continued to be used along with *ghaṭikā* and *ghaṭī*.

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0.2 Āryabhaṭa I was the first to describe the bowl of this water clock in his *Āryabhaṭasiddhānta.*[3] He describes it in the following words:

vṛttaṃ tāmramayaṃ pātraṃ kārayed daśabhiḥ palaiḥ/
ṣaḍaṅgulaṃ tadutsedho vistāro dvādaśānane//
tasyādhaḥ kārayec chidraṃ palenāṣṭāṅgulena tu/
ity etad ghaṭikāyantraṃ palaṣaṣṭyāmbupūraṇāt//
sveṣṭaṃ vānyad ahorātre ṣaṣṭyāmbhasi nimajjati/
tāmrapātram adhaśchidram ambuyantraṃ kapālakam//

Kripa Shankar Shukla's translation of this passage reads thus:

> 'One should get a hemispherical bowl made of copper, 10 *palas* in weight, six *aṅgulas* in height, and twelve *aṅgulas* in diameter at the top. At the bottom thereof, let a hole be made by a needle eight *aṅgulas* in length and 1 *pala* in weight.
>
> 'This is the *ghaṭikā-yantra*, (so named) because it is filled by water in a period of 60 *palas* (i.e. one *ghaṭī*).
>
> 'Any copper vessel made according to one's liking with a hole in the bottom, which sinks into water 60 times in a day and night, is the water instrument called *Kapāla.*'

Shukla obviously thought that this passage describes two different instruments, called respectively *Ghaṭikā-yantra* and *Kapāla-yantra.*[4] But the fact is that these are two different methods of producing one and the same *Ghaṭikā-yantra.* The first method is to take ten *palas'* weight of copper and with that to produce a hemispherical bowl, having a height of six *aṅgulas* and an upper diameter of twelve *aṅgulas.* There should be a fine perforation at the bottom of the bowl. The small size of the perforation is defined in a peculiar manner. It should be made, as Āryabhaṭa says, 'with [an object, say a needle, having a weight of] one *pala*

[3] This work is now lost, but luckily Āryabhaṭa's descriptions of various instruments survive in Rāmakṛṣṇa Ārādhya's commentary on the *Sūryasiddhānta.* Kripa Shankar Shukla published these passages in his paper 'Āryabhaṭa I's Astronomy with Midnight Day-Reckoning'.

[4] Accordingly, *Indian Astronomy: A Source-Book* reproduces these verses and their translation under two different heads, viz. 10.11.1: *Ghaṭikā-yantra* (p. 91) and 10.5.5: *Kapāla-yantra* (p. 89).

and a [length of] eight *aṅgulas*.' He does not specify what kind of metal is to be used for the needle. But since the weight and the length are prescribed, the implication is that a wire of uniform thickness and a specific length has to be produced from a given amount of the metal. Such metal could only be gold; it is malleable enough to be drawn into wires of uniform thickness. Indeed, in his *Arthaśāstra*, Kauṭilya prescribes that the outflow water clock (*nālikā*) should have a 'perforation by [a needle made of] four *māṣakas* of gold and four *aṅgulas* in length.'[5] It is highly probable that the unspecified metal in Āryabhaṭa's verse is also gold. But a thin gold needle cannot pierce through a copper bowl. Hence Āryabhaṭa's specification (and also Kauṭilya's) should be understood to mean that 'the perforation should be such that a gold wire, one *pala* in weight and eight *aṅgulas* in length, can pass through it.'[6]

Goldsmiths of that time may have been able to draw fine grades of gold wire, but whether they could draw a wire measuring exactly eight *aṅgulas* from a lump of gold weighing exactly one *pala* is open to question. However, the main purpose of the instrument is to measure one-sixtieth part of the nychthemeron. For this purpose, the bowl should be such that it fills with water and sinks into the basin sixty times in a day and night; in other words, the bowl should fill in a period of one *ghaṭikā*, or of sixty *palas*. Therefore, Āryabhaṭa goes on to suggest that the measurements of the bowl and of the needle are not so important; what is important is that the bowl should be able to fill with

[5] This system is employed for the first time in the *Kauṭilīya Arthaśāstra* for defining the perforation of the outflow water clock (*Nālikā-* or *Nāḍikā-yantra*); cf. 2.20.34: *suvarṇamāṣakāś catvāraś caturaṅgulāyāmāḥ kumbhacchidram āḍhakam ambhaso vā nālikā.*

[6] Similar specifications were given in other texts as well. The *Jyotiṣkaraṇḍaka* (verses 11-14) lays down that the hole of the outflow water clock (*nāligā*) should be such that ninety-six hairs from the tail of a three years' old female elephant calf, or twice that number from the tail of a two years' old female elephant calf, or a gold needle of four *māṣas*' weight and four *aṅgulas*' length should pass through it. Al-Bīrūnī (Vol. I, p. 334) cites from 'the book *Srûdhava* by Utpala the Kashmîrian': 'If you bore in a piece of wood a cylindrical hole of twelve fingers' diameter and six fingers' height, it contains three *manā* of water. If you bore in the bottom of this hole another hole as large as six plaited hairs of a young woman, not of an old one nor of a child, the three *manā* of water will flow out through this hole in one *ghaṭī*.' It may be noted that this is also an outflow water clock.

water sixty times in a day and night. This is the import of verse no. 31, where particle '*vā*' indicates that this is an alternative method. The word '*kapāla*' here is not the designation of another instrument, but denotes the hemispherical shape of the bowl. In this light, I retranslate the verse:

> 'Or, alternatively, any hemispherical (*kapāla*) copper vessel made according to one's liking with a perforation in the bottom, which sinks into water sixty times in a day and night, is the water clock (*ambu-yantra*).'[7]

0.3 Lalla, while retaining the weight and size of the bowl, changed the dimension of the perforation:

> *daśabhiḥ śulbasya palaiḥ pātraṃ kalaśārdhasannibhaṃ ghaṭitam/*
> *hastārdhamukhavyāsaṃ samaghaṭavṛttaṃ dalocchrāyam//*
> *satryaṃśamāṣakatrayakṛtanalayā samasavṛttayā hemnaḥ/*
> *caturaṅgulayā viddhaṃ majjati vimale jale nāḍyā//*[8]

> 'The bowl, which resembles half a pot (i.e. hemispherical), which is made of ten *palas* of copper, which is half a cubit (i.e. twelve *aṅgulas*) in diameter at the mouth and half (i.e. six *aṅgulas*) as high, which is evenly circular, and which is bored by a uniformly circular needle, made of three and one-third *māṣas* of gold and of four *aṅgulas* in length, sinks into clear water in one *ghaṭikā* (*nāḍī*).'

It is difficult to say what caused this shift in the size of the perforation—from the gold needle of one *pala* weight and eight

[7] Brahmagupta too does not prescribe any measurements for the bowl and the perforation. All that is required is that the bowl should sink sixty times in an *ahorātra*; cf. *Brāhmasphuṭa-siddhānta*, 22.41:

> *ghaṭikā kalaśārdhākṛti tāmraṃ pātraṃ tale 'pṛthu cchidram/*
> *madhye tajjalamajjanaṣaṣṭyā dyuniśaṃ yathā bhavati//*

'The *Ghaṭikā-yantra* is a copper vessel of the shape of a hemisphere. At the centre of the bottom is a small perforation so made that the bowl sinks sixty times in a day and night.' *Sūryasiddhānta*, 13.23 also gives a similar definition, without specifying the measurements:

> *tāmrapātram adhaśchidraṃ nyastaṃ kuṇḍe 'malāmbhasi/*
> *ṣaṣṭir majjaty ahorātre sphuṭaṃ yantraṃ kapālakam//*

[8] *Śiṣyadhīvṛddhidatantra*, Part I, 21 (*Yantrādhikāra*), 34–35.

aṅgulas' length to a gold needle three and one-third *māṣas* in weight and four *aṅgulas* in length.[9] According to Śrīdhara, who is a near contemporary of Lalla, sixty-four *māṣas* make one *pala*.[10] Then the perforation prescribed by Lalla would be 5/48th of that prescribed by Āryabhaṭa.[11] While the size and weight of the bowl remained the same, such stark reduction in the size of the perforation would have greatly increased the duration of the time needed for the bowl to become full and then to sink, and consequently the duration of the *ghaṭikā* as well. One is therefore led to suspect that these specifications for the size of the perforation in terms of a gold wire of certain weight and length are fictitious and have no connection with actual practice. Yet this latter specification for the size of the perforation is repeated in several subsequent works.

0.4 Bhāskara II dismisses these specifications of the size as impractical. According to him a bowl of any size with any arbitrary hole can serve as the water clock. It need not even have a duration of one *ghaṭikā*; a bowl of any duration will do for measuring time. Thus he declares in the *Siddhāntaśiromaṇi*:

> *ghaṭadalarūpā ghaṭitā ghaṭikā tāmrī tale 'pṛthucchidrā/*
> *dyuniśanimajjanamityā bhaktaṃ dyuniśaṃ ghaṭīmānam//* [12]
>
> 'A copper bowl, formed like a hemisphere, having a small (*apṛthu*) hole at the bottom. The duration of a day and night divided by

[9] Of course, Lalla also adds that the vessel and the perforation can be of any dimension, provided the bowl sinks in one *ghaṭī*: cf. *Śiṣyadhīvṛddhidatantra*, Part I, 21 (*Yantrādhikāra*), 36:

> *athavā svecchāghaṭitaṃ ghaṭīpramābhiḥ prasadhitaṃ bhūyaḥ /*
>
> 'Or, it is a vessel manufactured according to one's liking [with a perforation at the bottom] which has been adjusted by the measure of a *ghaṭī* by repeated [trials].' (Bina Chatterjee's translation, slightly modified.)

[10] *Pāṭīgaṇita*, Rule 10.

[11] Let A be the area of the cross section of the wire (and therefore the area of the hole produced by the wire) of 1 *pala* weight and 8 *aṅgulas*' length. Then its volume will be 8A. If a gold wire of 1 *pala* (64 *māṣas*) has a volume of 8A, then a gold wire of $3\frac{1}{3}$ *māṣas* will have the volume of $\frac{8A}{64} \cdot \frac{10}{3} = A \cdot \frac{5}{12}$. The gold wire of $\frac{10}{3}$ *māṣas* is 4 *aṅgulas* long. Then the area of its cross section $B = A \cdot \frac{5}{12} \cdot \frac{1}{4} = A \cdot \frac{5}{48}$.

[12] *Siddhāntaśiromaṇi, Golādhyāya, Yantrādhyāya*, 8, pp. 366–367.

> the number of immersions [of this bowl] gives the measure of the water clock.'

This statement is elaborated in his auto-commentary *Vāsanā-bhāṣya*: 'Here, we ignore the definition of the water clock given by certain scholars as '*daśabhiḥ śulbasya palair...*' because it is illogical (*yukti-śūnya*) and difficult to implement (*durghaṭa*).'[13]

Here Bhāskara is attacking Lalla directly by quoting the latter's definition of the water clock. In his view, such specifications for the size of the bowl and that of the perforation are impractical. On the other hand, by stating that a bowl with any duration of immersion will do, Bhāskara goes to the other extreme. If the bowl sinks, say, in thirty-four minutes and thus measures a period of thirty-four minutes each time it sinks, these periods have to be converted into *ghaṭikās* of twenty-four minutes. By not insisting that the bowl should sink in one *ghaṭikā*, as Āryabhaṭa and Brahmagupta did, Bhāskara underestimates the Indian artisan's ability to fabricate bowls of exactly one *ghaṭikā* duration.

0.5 There is yet another problem with Bhāskara II's statement. His diction (*ghaṭadalarūpā ghaṭitā ghaṭikā tāmrī tale 'pṛthucchidrā*) follows very closely that of Brahmagupta (*ghaṭikā kalaśārdhākṛti tāmraṃ pātraṃ tale 'pṛthu cchidram*).[14] Since the manuscripts rarely mark the *avaghraha* symbols, these have to be inserted according to the context by the modern readers. There is no way of knowing whether the author himself desires an *avagraha* at a certain point or not, unless this is spelt out clearly in a subsequent statement by the author himself, or in an auto-commentary or in a reliable commentary written by one who is close to the author in time or spirit. In the present case, it is uncertain whether Brahmagupta and Bhāskara II consider the perforation to be '*pṛthu*' or '*apṛthu*'. Bhāskara's auto-commentary is silent on this issue.

However, Bhāskara II's commentator Munīśvara (b. 1603) expressly prohibits the insertion of an *avagraha* here. Thus he argues in his *Marīci* commentary: 'The bowl should be so made

[13] Ibid, p. 367: *atra daśabhiḥ śulbasya palair ity ādi yad ghaṭīlakṣaṇaṃ kaiścit kṛtaṃ tad yuktiśūnyaṃ durghaṭaṃ cety etad upekṣitam /*

[14] See n. 6 above.

that it has a large hole (*pṛthucchidra* = *mahārandhra*) at the bottom. Through this statement it is indicated that the hole should be made in such a manner that, when the bowl is placed on the water of the basin and when water enters [the bowl], the hole is not blocked by any dirt that may be in the water of the basin. Because of the possibility of a small hole getting blocked by dirt and the like, assuming here a coalescence of the vowel *a* (*akāra-praśleṣa*) [by reading *apṛthu*] is not proper.'[15]

We do not know if this is the intention of Bhāskara II or if this is just Munīśvara's view.[16] But a large hole will certainly make the bowl sink very rapidly. If it sinks, for example, in ten minutes, then it has to be lifted, emptied and placed again on the surface of the water each ten minutes! There is no practical advantage in using a water clock of such short duration.[17] It is more likely, therefore, that Bhāskara intended to say '*apṛthu*'. All the extant specimens that I have seen have very small holes.

0.6 Besides the question of the size of the perforation, another misunderstanding seems to have arisen about the volume of the bowl. The basic requirement, as we saw, is that the bowl should sink sixty times in a day and night, or that it should become full of water in one *ghaṭī* of sixty *palas*. Āryabhaṭa expressed this as '*palaṣaṣṭyā ambupūraṇa*'. This seems to have been misunderstood to mean that the bowl should have the capacity to hold sixty *palas* of water. In his commentary on the *Āryabhaṭīya*, Bhāskara I mentions such a view, albeit as a *pūrvapakṣa*.[18] Since his discussion throws up many problems, it is necessary to quote his statement in full and then to analyse it:

> *katham punar divasasya ṣaṣṭibhāgaḥ sādhyate ity atrābhidhīyate/ atra kecid bruvate suvarṇarajatatāmrāṇām anyatamam pātram*

[15] *Siddhāntaśiromaṇi*, p. 367: *tale 'dhobhage pṛthucchidrā mahārandhrā ghaṭikā kāryā / etena jalapūrṇapātre nikṣiptādhaśchidre jalāgamane jalāntargatamalādikaṃ vastu pratibandhakaṃ na bhavati tathā chidraṃ kāryam iti sūcitam/ sūkṣmacchidre malādikena tatpratibandhasambhavād akāraprasleṣo na yuktaḥ/*

[16] The only other published commentary by Nṛsiṃha is silent on this issue; see p. 442 of Nṛsiṃha's commentary. See Bibliography.

[17] For preventing the blockage of the hole, it is generally prescribed that the water should be very clean.

[18] *Āryabhaṭīya*, p. 174.

ardhavṛttākāraṃ ṣaṣṭipalapānīyadhārakaṃ pūrakaṃ nisrāvakaṃ vā ghatiketi/ naiṣa niyamo [19] *yāvat palāni ṣaṣṭiḥ pānīyaṃ prasravaty āpūryate vā tāvatā nāḍikākāla iti/ prājñās tu naivam iti mayante/ kathaṃ tarhi/ ahorātraprasrutasya pānīyasya ṣaṣṭibhāgo ghaṭikāpramāṇa iti sthūlaḥ kalpaḥ/ sūkṣmas tu samāyām avanau nirdiṣṭākārasya śaṅkor ghaṭikāchāyām aṅkayitvā ghaṭikā sādhyate/ ghaṭikāchidraṃ ca chāyākālavaśād yuktyā yojayitavyam/*

'How then is the one-sixtieth part of a nychthemeron to be determined?' To this question, [the following] has to be said. In this connection some say: 'The *Ghaṭikā*[*-yantra*] is a vessel [made out] of one of the metals like gold, silver or copper, hemispherical in shape (lit. semicircular), which holds (*dhāraka*) sixty *palas* of water and which is filled with or discharges [the same amount of water].' Actually there is no such rule that the duration of the *ghaṭikā* (*nāḍikā-kāla*) is so long as it takes the vessel to discharge or to fill with sixty *palas* of water. Wise persons think that this is not so. How then?

'It is only a rough method (*sthūlaḥ kalpaḥ*) to say that the one-sixtieth part of the water that has been discharged in the course of a nychthemeron is the measure of one *ghaṭikā*. The more accurate method is to measure the *ghaṭikā* by marking the shadow of one *ghaṭikā*, cast by a gnomon of specified shape that has been set up on a level ground. The perforation in [the bowl of] the *Ghaṭikā-yantra* should be made skilfully according to the period measured by the shadow.'

Though Bhāskara I does not himself approve of it, there are some who hold that the *Ghaṭikā-yantra* should be a hemispherical vessel, which has the capacity to hold sixty *palas* of water and which either discharges or is filled with the same amount of water. Thus according to these persons both the outflow type of water clock which discharges water and also the sinking bowl type which is filled with water should have the same hemispherical shape and a volume of sixty *palas*. It is not known who these persons were who thought (already before 629 AD when Bhāskara wrote the commentary) that the bowl should have the capacity of sixty *palas*, but this notion continued to be held in later times as well.

Thus Śrīpati in his *Siddhāntaśekhara* prescribes that the bowl should hold sixty *palas* of water:

[19] The Edition reads *naiṣa niyamaḥ* and closes the sentence here. I combine this sentence with the next one in order to draw a coherent meaning.

śulbasya digbhir vihitaṃ palair yat
ṣaḍaṅguloccaṃ dviguṇāyatāsyam/
tad ambhasā ṣaṣṭipalaiḥ prapūryaṃ
pātraṃ ghaṭārdhapramitaṃ ghaṭī syāt//

satryaṃśamāṣatrayanirmitā yā
hemnaḥ śalākā caturaṅgulā syāt/

viddhaṃ tayā prāktanam atra pātraṃ
prapūryate nāḍikayāmbunā yat// [20]

'A vessel, resembling half a pot in shape (i.e. hemispherical), made of ten *palas* of copper, six *aṅgulas* in height and twice the same in the diameter of the mouth, which can be filled with sixty *palas* of water, is the *Ghaṭī-yantra*. It should be pierced beforehand by a four *aṅgulas* long gold needle that has been made of three and one-third *māṣas* [of gold]. Then it fills with water [and sinks] in one *ghaṭikā* (= *nāḍikā*).'

The expression '*tad ambhasā ṣaṣṣṭipalaiḥ prapūryaṃ*' can also be interpreted to mean that 'it should fill with water in a period of sixty *palas*' but then it would be redundant to say '*prapūryate nāḍikayāmbunā yat*'. Therefore, the first expression should pertain to the volume of the bowl. If the bowl really contains sixty *palas* of water, one *pala* would be either 8 or 7.6 cubic *aṅgulas*. *Pala* occurs as a unit of weight and also as a unit of time; but this is a rare use of *pala* as a unit of liquid measure. But the chances are that this too is a fictitious specification for the capacity of the bowl.

On the other hand, the time unit *pala* is occasionally referred to as '*pānīyapala*' in contexts where it is quite certain that it is a time unit. Thus Āryabhaṭa II speaks of six *asus* in one *pānīyapala*; and Bhaskara II of 3600 *pānīyapalas* in a day and night.[21] Probably here it means 'a *pala* that is measured by means of water clock' as distinct from '*pala*', the unit of weight.

0.7 A third problem is the occasional confusion between two types of water clocks, namely the sinking bowl type and the outflow type that preceded it chronologically. While the former fills

[20] *Siddhāntaśekhara* 19.19-20.

[21] See *Mahāsiddhānta*, 1.6: *prāṇāḥ pānīyapale tā; Siddhāntaśiromaṇi, Golādhyāya, Yantrādhyāya*, 8, *Vāsanābhāṣya: dyuniśanimajjanasaṃkhyayā yadi ṣaṭtriṃśacchatāni pānīyapalāni labhyante tadaikena kim iti trairāśikam.*

itself with water through a perforation and sinks in a fixed duration of time, the latter empties itself of water through a perforation in a fixed duration of time. In the previous paragraph we have seen that the *pūrvapakṣins* cited by Bhāskara I treat the vessels in both the types as hemispherical with the same volume. Or is it Bhāskara I himself who sees both the vessels as identical in shape and size? While the bowl in the sinking bowl type is certainly hemispherical or nearly so, this cannot be true of the outflow type, where the vessel must have had the shape of a regular cylinder or that of a truncated cone. Such confusion between the two types occurs elsewhere also. As we shall see below in 3.4.1-2, the *Dharmasindhu*, while discussing the sinking bowl type of water clock, cites in support a passage from the *Bhāgavata*, which describes the outflow type.

Sanskrit astronomical texts describe a large number of instruments. But no other instrument received such detailed specifications as the *Ghaṭikā-yantra* did. Again, of all the instruments described in these texts, the *Ghaṭikā-yantra* was the only one which was manufactured in great numbers and was used by astronomers and laymen alike. It is indeed strange that there should be such confusion in describing this simple instrument in all the highly 'scientific' texts on astronomy.

0.8 In spite of this theoretical confusion in the texts, countless specimens of this water clock were produced throughout the centuries and these kept reasonably correct time of one *ghaṭikā* of twenty-four minutes. But it is doubtful if any artisan has ever produced a bowl according to the textual prescriptions. In the few specimens that survive in modern collections,[22] rarely any bowl has the exact shape of a hemisphere; some are more conical, some are shallower, than a precise hemisphere. The sizes and weights too do not conform to the textual prescriptions, and vary considerably.

The holes were obviously made by a trial and error method, by comparing the new bowl with another bowl that shows correct time or with a sundial, as Bhāskara I recommends,[23] and by

[22] While cataloguing the extant specimens of Indian astronomical and time measuring instruments, I had occasion to study several water clocks.

[23] See 0.6 above.

suitably enlarging the hole or by reducing its size rather than by means of a gold wire of given dimensions. Sometimes the hole can become larger by constant use. Then the size of the hole can be reduced by hammering the area around the hole. In one case, a gold buff was added to the hole in order to reduce its size.[24]

0.9 There are evidences of timekeeping establishments in royal palaces, Buddhist monasteries, temple courtyards or town squares, maintained by royal or private endowments. Here time was constantly measured by this water clock and broadcast by conch and drum, or by the gong.[25] The Chinese traveller I-Tsing who spent some ten years from ca. 675 to 685 AD at the famous Buddhist monastery of Nalanda, gives a detailed description of the time keeping establishment there.[26] At the beginning of the eleventh century, al-Bīrūnī describes the time-keeping establishment at Purshor (modern Peshawar) and adds that 'Pious people have bequeathed for these clepsydrae (i.e. water clocks), and for their administration, legacies and fixed incomes.'[27] Epigraphic and literary records show that the institution of time keeping with the water clock and announcing it by means of the gong was adopted through all the centuries by royal courts (of the Tughluqs, Mughals, Rajputs, and even petty jamindars up to the beginning of the twentieth century), and also at places of worship belonging to the Hindu, Jain and Muslim faiths.[28]

1.0 Common householders could not afford the permanent installation of a water clock in their houses, for it needed the constant attendance of at least two people, one to announce the time when the bowl sinks and another to lift the bowl and place it again upon the water.[29] But householders too required the

[24] The bowl is now in the Museum of the Clockmakers' Company in London.

[25] For a photograph of the full ensemble of the bowl, vessel and gong, see Virendra Nath Sharma, 'Astronomical Instruments at Kota'.

[26] I-Tsing, *A Record of the Buddhist Religion*, pp. 144-145.

[27] Al-Bīrūnī, *Alberuni's India*, Vol. 1, pp. 337-338.

[28] Cf. S. R. Sarma, 'Astronomical Instruments in Mughal Miniatures'; idem, 'Indian Astronomical and Time-Measuring Instruments'; S. R. Sarma and Ishrat Alam, 'Announcing Time: The Unique Method at Hayatnagar 1676.'

[29] Actually, one needs at least six persons, namely two for each watch of eight hours.

water clock on special occasions like marriages, in order to know precisely the astrologically auspicious moment (*śubha-muhūrta* or *śubha-lagna*, or simply *muhūrta* or *lagna*). Usually the Purohita who performed the marriage brought the water clock with him and set it up ceremoniously in the client's house.[30]

1.1 The ritual connected with the setting up of the water clock and its invocation is described, albeit briefly, in an unpublished manuscript entitled *Ghaṭikāyantraghaṭanāvidhi*. This manuscript cites Nārada as the authority for this ritual. The extant version of the *Nāradasaṃhitā* (before 1365) does describe the ritual but the wording is somewhat different. Likewise Govinda Daivajña's *Pīyūṣadhārā* commentary (AD 1603) on his paternal uncle Rāma Daivajña's *Muhūrtacintāmaṇi* (AD 1600) and Kāśīnātha Upādhye's *Dharmasindhu* (AD 1790-91) describe the ritual, but with different wording. Unfortunately, the relevant passages in all these four sources are corrupt. But with the help of these sources, a hitherto unknown ritual connected with the water clock can be reconstructed. In the following pages, I shall first describe the ritual as gleaned from these passages. After that, I shall reproduce the text of the manuscript, and also three parallel passages from the other texts, suitably emended as far as possible, and provide a translation in English.

1.2 The *Ghaṭikāyantraghaṭanāvidhi* is a small paper manuscript of just three folios, now deposited in the Sarasvatī Bhavana of Sampūrṇānanda Saṃskṛta Viśvavidyālaya at Varanasi. The title *Ghaṭikāyantraghaṭanāvidhi* is mentioned at the beginning of the work. There are in all thirteen verses. These are followed by the expression '*atha maṅgalāṣṭakam*'. But before providing these eight auspicious verses, the manuscript breaks off abruptly. There is no colophon, nor any other indications to identify the author, scribe or the date. However, because of its close relation to some

[30] Cf. Edgar Thurston, *Ethnographic Notes in Southern India*, part II, p. 565: 'This form of time-measurer, made of half a cocoanut or copper, is still in use among native physicians, astrologers and others in Malabar. ... At the present day it is used on the occasion of marriage among higher Hindu castes. The brahmin priest brings the cup, and places the bridegroom in charge of it. It is the duty of the latter to count the gadis (= *ghaṭīs*) until the time fixed for his entrance into the wedding-booth.'

texts which belong to the early years of the seventeenth century, it is possible that the text of the present manuscript (if not the manuscript itself) also belongs to the early seventeenth century.

1.3 The ritual consists of (i) setting up the basin (*kuṇḍa*) on a sacred ground; (ii) placing the bowl therein at sunrise or sunset; (iii) the *mantra* in praise of the water clock; (iv) prognostication (*phala*) according to the cardinal direction to which the bowl moves when placed on the surface of the water in the basin; (v) and prognostication according to the direction in which the bowl finally sinks; and (vi) the recitation of the so-called *pala-vṛttas*.

1.4 All the four texts begin with the measurements of the bowl and the definition of the perforation. Here all the texts are highly corrupt. The confusion we have already noticed in astronomical texts is multiplied here many times. Though the *Yajamāna* is not expected to fabricate the bowl of the water clock as part of the ritual, the dimensions of the bowl and its perforation became part of the ritual text. And this too was apparently recited in course of the ritual. In a story contained in the *Kathāratnākara* which Hemavijaya Gaṇin composed in AD 1600 in Ahmedabad, there is an account of a Brāhmaṇa setting up the water clock for telling the time of his daughter's marriage, which runs thus:

> 'The Brāhmaṇa, who is especially well-versed in the whole range of astral science, wore a forehead mark made of saffron and rice-grains—
>
> 'The round vessel is made of ten *palas* of copper. In the *ghaṭikā* [bowl] the height should be made of six *aṅgulas*. The diameter there should be made to the measure of twelve *aṅgulas*. The good cherish a water clock that holds sixty *palas* of water.
>
> '—dropped the bowl, made fully according to the aforementioned prescriptions, in a basin filled with clean water at the time of the setting of the divine Sun.'[31]

[31] *Kathāratnākara*, pp. 539-40:

viśeṣato niḥśeṣajyotiḥśāstrakuśalo vinirmitakuṅkumataṇḍulatilakaḥ sa viprah
daśatāmrapalāvartapātre vṛttīkṛte sati/
ghaṭikāyāṃ samutsedho vidhātavyaḥ ṣaḍaṅgulaḥ//
viṣkambhaṃ tatra kurvīta pramāṇād dvādaśāṅgulam/
ṣaṣṭ[y]ambhaḥpalapūreṇa ghaṭikā sadbhir iṣyate//
ityādiparipūrṇapramāṇopetaṃ ghaṭikāpātraṃ svacchanīrabhṛte kuṇḍe bhaga-

The weight and the size of the bowl are not relevant to the story. Yet these are mentioned but not the hole, which plays a role in the story: it gets blocked—not by some dirt in the water of the basin, but by a rice grain that got itself detached from the Brāhmaṇa's forehead mark and fell into the bowl—and the auspicious moment for the marriage lapses.

1.5 While the ritual sometimes preserves archaic technical processes, frequent recitation in the ritual of passages that are not immediately relevant and therefore are not clearly understood can lead to their distortion as well.[32] Both these processes occur in the case of the *Ghaṭikā-yantra*. Even today, in temples at Mathura, the midnight hour of Kṛṣṇa's birth is measured by this water clock. Thus ritual preserves an archaic practice of time measuring. But the passages containing the measurements of the bowl get distorted by constant repetition, because the Brāhmaṇa priests do not produce the bowl themselves, and the measurements are of no interest to them. These distortions can be seen in ample measure in the four texts which will be presented below. The *Ghaṭikāyantraghaṭanāvidhi* and the *Nāradasaṃhitā* provide the dimensions of the bowl and its perforation, not once but twice, ostensibly as two alternative methods (*prakārāntara*) but actually the same method from two different sources, and both times the prescriptions are garbled. The *Dharmasindhu*, on the other hand, mixes up the prescriptions for the sinking bowl type and the outflow type. Nevertheless, these passages are of interest from the viewpoint of cultural history and the process of text transmission. In my translation of these passages, I shall try to explain how certain distortions may have taken place.

2.1 It is prescribed that the ground where the basin is to be set up should be sloping to the east and to the north and be smeared with cow dung. On this ground, some grains of rice are sprinkled and a jewel or a piece of gold is placed. The basin, of copper or clay, is placed upon the grains of rice. According to the

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vato bhānor astagamanasamaye mumoca/

[32] For an engaging account of similar distortions in modern times, see Madhav M. Deshpande, 'Contextualizing the Eternal Language: Features of Priestly Sanskrit'.

Nāradasaṃhitā, the basin is wrapped in a pair of clothes. The *Pīyūṣadhārā* adds that it should be decorated with sandal paste and flowers. Then it is filled with clean water.

2.2 The measuring of time, i.e. the counting of the *ghaṭīs*, starts either at sunrise or sunset as the case may be. This moment is defined in our passages as 'when half of the Sun's orb has risen or set.' At this moment the bowl should be placed on the water in the basin. Before placing the bowl, Gaṇeśa and the Sun are worshipped, so also the personal deity and the teacher of the householder who is the bride's father.

2.3 While placing the bowl upon the water in the basin, the bowl is addressed with a sacred formula which is said to have been composed by Nārada. However, the text of the formula varies in all the four sources; the one cited in the *Pīyūṣadhārā* shows the greatest divergence. The original text may be that which occurs in the *Nāradasaṃhitā*; a variation of this can be seen in the *Ghaṭikāyantraghaṭanāvidhi* and an elaboration of the same in the *Pīyūṣadhārā*.

Nāradasaṃhitā:

mukhyaṃ tvam asi yantrāṇāṃ brahmaṇā nirmitā purā//
bhavābhayāya dampatyoḥ kālasādhanakāraṇam/

Dharmasindhu:

mukhyaṃ tvam asi yantrāṇāṃ brahmaṇā nirmite purā/
bhava bhāvāya dampatyoḥ kālasādhanakāraṇam//

Ghaṭikāyantraghaṭanāvidhi:

yantrāṇāṃ mukhyarūpāsi brahmaṇā nirmite ghaṭi/
dampatyoḥ śubhakālāptihetave bhava śobhane//

Pīyūṣadhārā:

yantrāṇāṃ mukhyayantraṃ tvam iti dhātrā purā kṛtam/
dampatyor āyuvṛddhyardhaṃ putrādidhanahetave/
jalayantraka me tasmād iṣṭasiddhiprado bhava//

2.4 When the bowl is placed on the water, it does not remain stationary where it is placed. It keeps turning until it settles at some place, generally towards the edge of the basin. The cardinal direction where it settles is said to be indicative of future portents. Likewise, the direction where it sinks is used for prognostication.

Besides the *Ghaṭikāyantraghaṭanāvidhi*, only the *Dharmasindhu* contains this section. According to both the sources, the result is not beneficial if the bowl settles or sinks in any one of the following four directions, viz. south-east, south, south-west and north-west. Furthermore, if the bowl sinks in the west, it is also not beneficial; on the other hand, sinking in this direction is said to be beneficial; it is even said that the girl becomes the favourite — obviously of the in-laws.

2.5 In the *Ghaṭikāyantraghaṭanāvidhi*, this prognostication is followed by three verses the contents of which do not have any apparent relation with one another or with the subject of the water clock. Fortunately, in the story from the *Kathāratnākara* which has been mentioned above, there is a reference to the recitation of '*pala-vṛttas*': 'The Brāhmaṇa placed the bowl of the water clock in a vessel containing clear water at the time of the setting of the divine Sun. Because he was busy reciting the *pala-vṛttas* such as '*mā kānte pakṣasyānte parvākāśe svāpsīḥ...*'[33] This is the first line of the first of the three verses in our manuscript. The story narrates that, after placing the bowl upon the water of the basin, the Brāhmaṇa recited this and similar *pala-vṛttas*. Therefore all the three verses in our manuscript must be *pala-vṛttas* that are recited after placing the perforated bowl upon the water in the basin. What then does the expression '*pala-vṛtta*' mean and why must these be recited?

The first of these three verses occurs also in Bhāskara I's commentary on the *Āryabhaṭīya*.[34] There Bhāskara explains that the time taken to utter sixty long syllables (*guru-akṣaras*) is one *vināḍikā*, and then cites the first of our three verses which consists exactly of sixty long syllables. '*Pala*' being a synonym of *vināḍikā*, *pala-vṛtta* designates a verse consisting of sixty long syllables, the reciting of which takes one *pala* of time, i.e. twenty-four seconds.

Indeed all the three verses at the end of our manuscript are such '*pala-vṛttas*'. Why should they be recited? The *Ghaṭikāyantra* can measure the period of one *ghaṭikā* of twenty-four minutes. For measuring smaller periods of time, it is likely that one

[33] *Kathāratnākara*, p. 540: *ghaṭikāpātraṃ svacchanīrabhṛte kuṇḍe bhagavato bhānor astagamanasamaye mumoca/ mā kānte pakṣasyānte parvākaśe svāpsīḥ ityādi-pala-vṛtta-paṭhanato ...*

[34] *Āryabhaṭīya*, p. 175.

recited the appropriate number of these *pala-vṛttas*.[35] It is possible that in the early seventeenth century when the *Kathāratnākara* was composed and also when the *Ghaṭikāyantraghaṭanāvidhi* may have been put together, the main function of these verses was forgotten and that they were just recited, without being employed for measuring the fractions of the *ghaṭikā*, just as one recited the verses about the measurements of the bowl and of its perforation. Nevertheless, the manuscript preserves three verses which were meant to measure time, no matter whether they were so used or not. The first verse is also the oldest; for it was quoted by Bhāskara I in his commentary which he completed in AD 629.[36] The second verse seeks the blessings of all the heavenly bodies for the couple and the third verse celebrates the ten incarnations of Viṣṇu. In Sanskrit prosody, such verses containing fifteen long syllables in each quarter are named variously as *Kāmakrīḍā, Līlākhela* and so on. The last two verses are benedictory in nature. It is quite appropriate to recite them in the context of a marriage ritual. But the first verse is of a different nature. It is not clear how it came to be connected with this ritual.

I now reproduce the four passages. Orthography and *sandhi* are silently corrected. Occasionally numerical expressions are followed by numeral symbols, e.g. *daśa 10*; such numbers are omitted. Wherever the wording has been emended, the original reading of the manuscript (MS) or of the edition (Edn) is shown in the footnotes.

3.1.1 *Ghaṭikāyantraghaṭanāvidhiḥ* [37]

śrīgaṇeśāya namaḥ/ atha ghaṭikāyantraghaṭanāvidhiḥ/

śuddhaṃ tāmravinirmitaṃ daśapalaiḥ [38] *pātraṃ ghaṭārdhākṛti* [39]

[35] S. R. Sarma, 'Measuring Time with Long Syllables'.

[36] Principal Vaman Shivaram Apte's *The Practical Sanskrit-English Dictionary*, revised and enlarged edition, Poona 1957, Appendix A: Sanskrit Prosody, p. 1, cites this verse to illustrate the metre *Līlākhela*, attributing it to the *Sarasvatīkaṇṭhābharaṇa*. But the verse does not occur in this text.

[37] For kindly providing me with a xerox copy of this manuscript, I am grateful to Professor Vidya Niwas Misra, the then Kulapati of the Sampūrṇānanda Saṃskṛta Viśvavidyālaya, and to Dr B. N. Misra, the then Librarian of the Sarasvatī Bhavana.

[38] MS: *rasa6palaiḥ*

[39] MS: °*kṛtiṃ*

mūlād ūrdhvaṣaḍaṅgulaṃ samaghanaṃ vistārato dvādaśa/ [40]
viddhaṃ svarṇaśalākayā tripacayā (?) māṣaikayā tadghaṭīṃ
mittvā [41] *vai palaṣaṣṭivārapatanāc* [42] *cet pūrita sā ghaṭī//1//*

atha prakārāntaram/

ardhodayaṃ vāstamayaṃ suvīkṣya
yantraṃ pradadyāj jalapūrṇapātre/
ṣaḍaṅgulotsedhasamaṃ suvṛttaṃ
kṛtaṃ mukhaṃ yad [d]virasāṅgulaṃ tat//2//
palais tu tāmrair daśabhir jalasya
pūrṇaṃ palaiḥ ṣaṣṭibhir ambuyantram/
satryaṃśamāṣatritayaiva vṛt[t]a-
śalākayā madhyamabhāgaviddham//3//
samudrasaṃkhyāṅgulidīrghayopa-
deśān mayūraṃ naravānarādyam (!)/
gurvakṣaraiḥ khendumitair asus taiḥ
ṣaḍbhiḥ palaṃ tair ghaṭikā khaṣaḍbhiḥ [43] *//4//*

atha ghaṭīsthāpanabhūlakṣaṇam/

prāgudagpravaṇe deśe gomayenopalepite/
mṛnāyaṃ (?) kuṇḍikāpātraṃ [44] *sthāpayed avraṇaṃ śubham//5//*
kuṅkumāktena sūtreṇa pariveṣṭya parasparam/
svacchena variṇā pūrṇaṃ taṇḍulānāṃ tathopari //6//
niścale salile sthapyaṃ kuṇḍikāyāṃ jalopari/
sthāpayed ghaṭikāyantraṃ sūryabimbārdhadarśanāt/
gaṇeśārkau ca saṃpūjya guruṃ natveṣṭadevatām//7//

[atha] ghaṭīsthāpanamantraḥ/

yantrāṇāṃ mukhyarūpāsi brahmaṇā nirmite ghaṭi/
dampatyoḥ śubhakālāptihetave bhava śobhane//8//

atha prāgādimadhyāntaghaṭībhramaṇaphalam āha/

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[40] MS: *vistārataḥ saptakaṃ* 7
[41] MS: *bhittvā*
[42] MS: °*paṭhanāc*
[43] MS: *khaṣaṣṭhiḥ*
[44] MS: *kuṇḍikāyugmaṃ*, which is obviously wrong. Only one basin is needed. Probably the corruption stems from '*vastrayugma*' in *Nāradasaṃhitā* 92.

yadrūpaṃ bhramaṇaṃ karoti ghaṭikā prāgādimadhyaṃ kramāt
saubhāgyaṃ [45] *nidhanaṃ vadhūmṛtisamaṃ yuktā ca rogais tanuḥ*[46]*/*
kanyā vallabhatām upaiti [47] *gaṇikātulyā yadā(?) dimaṃ*
syāt sādhvī sutavittabandhusahitā madhyasthitāryapradā//9//
uttareśānapūrvāsu ghaṭī pūrṇā śubhapradā/
dikṣu śeṣāsu kanyāyāḥ magnā vaidhavyadā smṛtā//10//
mā kānte pakṣasyānte paryākāśe deśe svāpsīḥ
kāntaṃ vaktraṃ vṛttaṃ pūrṇaṃ candraṃ matvā rātrau cet/
kṣutkṣāmaḥ prāṭaṃś cetaś ceto rāhuḥ krūraḥ prādyāt [48]
tasmād dhvānte harmyasyānte śayyaikānte kartavyā//11//
mārtāṇḍas tārānāthaḥ kṣoṇīsūnuḥ sūnuś cendor
vāgīśo daityācāryaś chāyāputro rāhuḥ ketuḥ/
nakṣatrair aśvinyādyais tārāyuktaiś cābhiḥ sarve
kuryāsuḥ [49] *kalyāṇaṃ vo nityārogyaṃ lakṣmīm āyuḥ//12//*
lokakṣemayāsīn matsyaḥ kūrmaḥ kroḍaḥ puṃsiṃho [50]
yo hrasvākāro rāmo [51] *rāmaḥ kṛṣṇo buddhaḥ* [52] *kalkī/*
evaṃ nānārūpaṃ nānākāraṃ nānānāmānaṃ
yogidhyeyaṃ devaṃ devānāṃ [53] *vande 'haṃ govindam//13//*

atha maṅgalāṣṭakam/

3.1.2 Translation

Salutation to śrī Gaṇeśa.

Now the method of setting up the water clock.

A pure vessel, made of copper of ten *palas* in weight, of the shape of a hemisphere, measuring six *aṅgulas* from the bottom to the top, evenly dense, in width twelve *aṅgulas*; pierced by a golden needle, made of one *māṣa* increased by three (*tripacayā*?). After

[45] MS: *saubhāgyaṃ na*
[46] MS: *rogaiś canuḥ*
[47] MS: *upaiti ka*
[48] MS: *prādyāt krūraḥ*
[49] MS: *kuyāsuḥ*
[50] MS: *puṃsīghe*
[51] MS: *romo*
[52] MS: *bauddhaḥ*
[53] MS: *devānāṃ devaṃ*

measuring with that vessel, if it sinks sixty times (or, if it is filled in sixty *palas* of time), then it is a [proper] water clock.//1// [54]

Now another method. [55]

After carefully observing the rise of the Sun's orb up to the half, or the setting of the same, the instrument (i.e. the bowl) should be placed in a basin filled with water. The bowl is so made that its height is equal to six *aṅgulas*, and the circular opening is twelve *aṅgulas* in diameter.//2//

The water clock (*ambu-yantra*) is made of ten *palas* of copper; it is filled by water in sixty *palas*.[56] It is pierced at the central portion (i.e. centre of the bottom) by a round needle made of three and one-third *māṣas* of gold,//3//

and 4 *aṅgulas* length; ... [57] Ten long syllables (*gurvakṣaras*) make one breath (*asu*); six of these make one *pala*; sixty of these make one *ghaṭikā*. //4//

Now the characteristics of the ground on which the water clock is to be set up.

On a ground, sloped to the east and north,[58] which has been smeared with cow-dung, a vessel called *kuṇḍa*, faultless (*avraṇa*) and auspicious, should be placed ... //5//

upon grains of rice and should be encircled with thread dyed in saffron; then it should be filled with clear water.//6//

The water clock (i.e. the bowl) should be placed on the placid water in the basin, when the Sun's orb is half visible, after worshipping Gaṇeśa and the Sun, and after bowing to the teacher and to the personal deity.//7//

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[54] The verse is highly corrupt; besides messing up the measurements, the last line telescopes two separate prescriptions, viz. *ṣaṣṭivārapatana* 'sinking sixty times in a nychthemeron' and *palaṣaṣṭyā pūraṇa* 'filling in a period of sixty *palas*'.

[55] What follows it not exactly another method, but rather the same information from another source.

[56] This can also mean 'it is filled by sixty *palas* of water'.

[57] Here the verse is contaminated by some irrelevant material '*upadeśān mayūraṃ naravānarādyam*', apparently from *Sūryasiddhānta* 13.21b: *toyayantrakapālādyair mayūranaravānaraiḥ//*

[58] Sloping to the east and north is considered to be auspicious; Cf. *Rāmāyaṇa* (vulgate edition), 2.99.24: *prāgudagpravaṇāṃ vediṃ viśālāṃ dīptapāvakām.* In its stead the Critical Edition chose a reading which makes no sense. 2.93.23:

prāgudakśravaṇāṃ vedīṃ viśālāṃ dīptapāvakām/
dadarśa bharatas tatra puṇyāṃ rāmaniveśane//

The sacred formula (*mantra*) for placing the water clock:

'O Water Clock, you have been created by Brahmā as the foremost among the [time measuring] instruments. O auspicious one, be the means for measuring the auspicious time [for the wedding] of the couple.' //8//

Now he tells the fruit of the rotation of the bowl, starting from the east etc., and ending in the middle.

According as the bowl rotates in cardinal directions from the east up to the middle of the basin, it causes respectively the good fortune of having the husband alive and devoted (*saubhāgya*), death, near death of the bride (*vadhūmṛtisama*), the body full of diseases, the girl becomes the favourite [of all], resembles a courtesan, (?) virtuous, endowed with sons, wealth and relatives. Staying in the middle, [the bowl] grants noble [sons].//9//

If the bowl becomes full (*pūrṇā*) [and sinks] in the north, north-east, or in the east, it bestows auspiciousness; if it sinks (*magnā*) in the remaining directions, it is said to inflict widowhood on the girl.//10//

[Now the *pala*-verses]:

Do not, O pretty one, at the end of the bright fortnight, sleep at a place open to the sky. Should it turn night, the cruel Rāhu, starving with hunger and roaming hither and thither, may eat you up, taking your pretty round face for the full moon. Therefore, after darkness, make your bed at a secluded place inside the house.//11//

May the Sun, the Moon, Mars, Mercury, Jupiter, Venus, Saturn, Rāhu and Ketu, all these, together with the lunar mansions beginning with Aśvinī, and all these stars, produce auspiciousness, constant good health, prosperity, and longevity [for the couple].//12//

For the welfare of the world, there [manifested the incarnations of] the Fish, the Tortoise, the Boar, the Man-Lion, One who had a Short Stature, [Paraśu] Rāma, Rāma, Kṛṣṇa, Buddha and Kalkin. I bow to Govinda, the god of gods, who in this manner assumed diverse forms, diverse shapes and diverse names, and who is meditated upon by sages.//13//

Now the eight auspicious verses.

3.2.1 *Nāradasaṃhitā* [59]

tallagnaṃ jalayantreṇa dadyāj jyotiṣikottamaḥ/
ṣaḍaṅgulamitotsedhaṃ dvādaśāṅgulam āyatam//86//
kuryāt kapālavat tāmrapātraṃ tad daśabhiḥ palaiḥ/
pūrṇaṃ ṣaṣṭir jalapalaiḥ ṣaṣṭir majjati vāsare//87//
māṣatrayatryaṃśayutasvarṇavṛttaśalākayā [60]*/*
caturaṅgulāyatayā [61] *tathā viddhaṃ parisphuṭam//88//*
kāryeṇābhyadhikaḥ (?) ṣaḍbhiḥ palais tāmrasya bhājanam/
dvādaśa mukhaviṣkambha utsedhaḥ ṣaḍbhir aṅgulaiḥ//89//
svarṇamāṣena vai kṛtvā caturaṅgulakātmakaḥ/
madhyabhāge tathā viddhā nāḍikā ghaṭikā smṛtā//90//
tāmrapātre jalaiḥ [62] *pūrṇe mṛtpātre vāthavā śubhe/*
gandhapuṣpākṣataiḥ sārdham [63] *alaṃkṛtya prayatnataḥ//91//*
taṇḍulasthe svarṇayute vastrayugmena veṣṭite/
maṇḍalārdhodayaṃ vīkṣya raves tatra vinihkṣipet//92//
mantreṇānena pūrvoktalakṣaṇaṃ yantram uttamam/
mukhyaṃ tvam asi yantrāṇāṃ brahmaṇā nirmitā purā//93//
bhavābhayāya dampatyoḥ kālasādhanakāraṇam/

3.2.2 Translation

The best of the astrologers should measure (*dadyāt*) [64] that auspicious moment by means of the water clock. With a height of six *aṅgulas*, with a width of twelve *aṅgulas*,//86//

let a copper bowl be made, like a hemisphere, with ten *palas* of weight. It is filled in the duration of sixty *palas* (or, with sixty *palas* of water), and sinks sixty times in a day and night. [65] //87//

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[59] *Nāradasaṃhitā*, 29.86-95, pp. 181-184.
[60] Edn: *māṣamātratryaṃśayutaṃ svarṇa°*
[61] Edn: *caturbhir aṅgulair āpas*
[62] Edn: *jalaḥ*
[63] Edn: *sārdhair*
[64] '*lagnaṃ dadyāt*' is an interesting expression.
[65] See section 0.7 above.

It should be pierced with a circular gold needle of three and one-third *māṣas* in weight and four *aṅgulas* in length. Then it is accurate.//88//

A copper bowl should be made with more than six *palas* (sic!). The diameter of the opening is twelve and the height six *aṅgulas*. //89//

Having made with one (sic!) *māṣa* of gold [a needle that is] four *aṅgulas* [in length], [with that] when the bowl (*ghaṭikā*) is pierced thus in the middle, it is then known as the water clock (*nāḍikā*).//90//

In an auspicious copper basin, or in a clay basin that has been filled with water, having decorated it with effort by means of sandal paste, flowers and coloured rice,//91//

the basin which is placed upon grains of rice, to which a gold piece is added and which is covered by a pair of clothes, one should place the bowl after having seen the rise of half of the Sun's orb.//92//

With this formula, one should deposit the best of the instruments, endowed with the aforementioned characteristics: 'You have been created a long time ago by Brahmā as the foremost among the [time measuring] instruments. For the safety (*abhaya*) of the couple, you become the means of measuring the time [of their wedding].' //93//

3.3.1 *Pīyūṣadhārā* [66]

sa ceṣṭakālaḥ kathaṃ sādhanīya ity ata āha kaśyapaḥ/
evaṃ guṇagaṇān vīkṣya lagnaṃ niścitya yatnataḥ/
siddhāntoktena mārgeṇa lagnakālaṃ prasādhayet//1//
jalayantreṇa tallagnaṃ dadyāt tenārcito dvijaḥ/
mukhaṃ dvādaśabhir vṛttam [67] *aṅgulaiś ca ṣaḍ unnatam//2//*
ghaṭārdhavat tāmrapātraṃ kuryāt tad daśabhiḥ palaiḥ/
ṣaṣṭir majjaty [68] *ahorātre ghaṭikāpātram uttamam//3//*
māṣatrayatryaṃśayutasvarṇavṛttaśalākayā/
caturbhir aṅgulair āyatayā viddhaṃ sphuṭaṃ nyaset//4//
raver ardhodayaṃ dṛṣṭvā vāpy ardhāstamayaṃ tathā/
pūrvoktalakṣaṇaṃ yantraṃ mantreṇānena niḥkṣipet//5//

[66] *Pīyūṣadhārā*, p. 424. The verse numbers have been added.
[67] Edn: *vṛttaṃ dvādaśabhir*
[68] Edn: *bhajed*

niḥkṣipej jalapūrṇapātra ity arthaḥ// yad āha Nāradaḥ//

tāmrapātre jalaiḥ pūrṇe gandhapupṣair alaṃkṛte/
taṇḍulasthe ratnayute śucibhūmāv ahaspateḥ [69]*/*
maṇḍalārdhodayaṃ vīkṣya jalapātre viniḥkṣipet//6// iti//

mantram apy āha sa eva/

yantrāṇāṃ mukhyayantraṃ tvam iti dhātrā purā kṛtaṃ/
dampatyor āyuvṛddhyarthaṃ putrādidhanahetave/
jalayantraka me tasmād iṣṭasiddhiprado [70] *bhava//7// iti//*

3.3.2 Translation

How is that desired auspicious moment of time to be determined: in reply to this question, Kaśyapa spoke thus:

In this manner, after considering all the good points, and having chosen, with effort, the auspicious moment (*lagna*) according to the method taught by the Siddhāntas, the time of that auspicious moment should be calculated (*prasādhayet*).//1//

Let the Brāhmaṇa, who had been honoured by him (i.e. the householder) measure that moment (*lagnaṃ dadyāt*) by means of a water clock.[71] Let a copper bowl be made with ten *palas* weight, like a hemisphere, with the circular mouth measuring twelve *aṅgulas* in diameter and six *aṅgulas* in height. If it sinks sixty times in a day and night, it is the best water clock. //2-3//

The bowl that has been clearly pierced by a circular needle of gold, of three and one-third *māṣas*' weight and four *aṅgulas*' length, should be placed [on the water].//4//

After having seen the rise of half of the Sun's orb, or the setting of the half likewise, the instrument having the aforementioned characteristics should be deposited, with this sacred formula. //5//

'Should be deposited' means 'in a basin filled with water'. Thus spoke Nārada:

In a copper basin, which is filled with water, which is decorated with sandal paste and flowers, which is situated upon grains of rice on a pure ground, and which is endowed with jewels (*ratnayuta*), after noticing the rise of half of the Sun's orb, [the bowl] should be deposited. //6// He also taught the sacred formula:

[69] Edn: *aharpateḥ*

[70] Edn: °*pradaṃ*

[71] Note the distinction between the two expressions '*lagnaṃ prasādhayet*' and '*lagnaṃ dadyāt.*'

'You have been created a long time ago by Brahmā as the foremost among the [time measuring] instruments. Therefore, for increasing the longevity of the couple and for conferring on them sons, wealth and the like, O water clock of mine, grant them the fulfilment of their desires.' //7//

3.4.1 *Dharmasindhuḥ* [72]

atha lagnaghaṭīsthāpanam/ daśapalamitatāmraghaṭitaṃ ṣaḍaṅgulonnataṃ dvādaśāṅgulavistṛtaṃ ghaṭī-yantraṃ kuryād iti Sindhuḥ/

dvādaśārdhapalonmānaṃ caturbhiś caturaṅgulaiḥ/
svarṇamāṣaiḥ kṛtacchidraṃ yāvat prasthajalaplutam//

iti tu śrībhāgavate tṛtīyaskandha uktam/ asyārthaḥ asītiguñjātmakaḥ karṣaḥ/ asyaiva suvarṇasaṃjñā/ karṣacatuṣṭayaṃ palam/ tathā ca ṣaṭpalatāmraviracitaṃ pātraṃ viṃśatiguñjonmitasuvarṇanirmitacaturaṅguladīrghaśalākayā mūle kṛtacchidraṃ kuryāt/ tena chidreṇa yāvat prasthaparimitaṃ jalaṃ praviśati tena ca prasthajalapūraṇena tat pātraṃ jale magnaṃ bhavati tat pātraṃ ghaṭīkālapramāṇam/ tatra prasthamānaṃ tu ṣoḍaśapalātmakam/

palaṃ suvarṇāś catvāraḥ kuḍavaḥ prastham āḍhakam/
droṇaṃ ca khārikā ceti pūrvapūrvacaturguṇam//

ity ukteḥ/ granthāntare caturmuṣṭiḥ kuḍavaś catvāraḥ kuḍavāḥ prastha iti/ kecit ṣaṣṭisaṃkhyākaguruvarṇoccār[aṇ]e palasaṃjñakālaḥ ṣaṣṭipalakālo nāḍikety āhuḥ/ evaṃ pramāṇīkṛtaṃ ghaṭīyantraṃ sūryamaṇḍalasyārdhodaye 'ste vā jalapūrṇe tāmrapātre mṛtpātre vā kṣipet/ tatra mantraḥ/

mukhyaṃ tvam asi yantrāṇāṃ brahmaṇā nirmite purā/
bhava bhāvāya dampatyoḥ kālasādhanakāraṇam//

anena mantreṇa gaṇeśavaruṇapūjanapūrvakaṃ ghaṭīyantraṃ sthāpayet/ evaṃ sthāpitā ghaṭī āgneyayāmyanairṛtavāyavyādidiggatā na śubhā/ madhyasthitānyadiggatā ca śubhā/ evam āgneyādi pañcadikṣu pūrṇā na śubhā// iti ghaṭīvicāraḥ

3.4.2 Translation

Now the setting up of the water clock [for measuring] the auspicious moment.

[72] *Dharmasindhu*, pp. 510-511.

The *Sindhu* declares that the water clock should be made of ten *palas* of copper, six *aṅgulas* high and twelve *aṅgulas* wide.

'[A vessel made of] half of twelve *palas*' weight, in which a hole has been made [with a needle of] four *māṣas* of gold and four *aṅgulas* [in length], till it is filled by (?) one *prastha* of water.'

Thus it has has been said in the third *Skandha* of the sacred *Bhāgavata.* [73] Its meaning is [as follows]. Eighty *guñjas* make one *karṣa.* The same has the designation of *suvarṇa.* Four *karṣas* are one *pala.* Thus, a vessel should be made of six *palas* of copper; it should be pierced at the base by means of a needle made of twenty *guñjas*' weight of gold and four *aṅgulas* in length. Through this perforation, by the time a *prastha* measure of water enters, that bowl sinks in the water, because of the *prastha* measure of water that filled it. Then that vessel becomes the standard measure for the period of one *ghaṭī.* There the unit of one *prastha* contains sixteen *palas.* [74]

For it has been said: one *pala* is four *suvarṇas*; then *kuḍava, prastha, āḍhaka, droṇa* and *khārikā*, are respectively each four times the previous unit.

In another text, it has been said that four fistfuls are one *kuḍava*, four *kuḍavas* are one *prastha.*

Some others say that the time taken for uttering sixty long syllables is one *pala*, and that the duration of sixty *palas* is one *nāḍikā.* The water clock, thus calibrated, should be placed in a copper basin or clay basin, full of water, when half of the Sun's orb has risen or set. There this sacred formula is recited.

'You have been created long time ago by Brahmā as the foremost among the [time measuring] instruments. For the sake of the

[73] *Bhāgavata* 3.11.9.

[74] What is described in the *Bhāgavata* is the outflow type of water clock. Here the perforation is made by a gold needle of four *māṣas* (= twenty *guñjas*) in weight and four *aṅgulas* in length, cf. *Kauṭilīya Arthaśāstra* and *Jyotiṣkaraṇḍaka*, cited in n. 4 and n. 5 above. The volume of the water discharged by this clock in a fixed period of time is one *prastha.* In this type of clock, water does not enter (*pra-viśati*) but flows out (*niḥsarati*). Similar confusion occurs elsewhere also. For example, while the *Jyotiṣkaraṇḍaka* describes the water clock of the outflow type, the commentator Malayagiri interprets the passage in the sense of the sinking bowl type. I shall discuss these two types elsewhere in greater detail. Finally, after a long and tire some excursion into metrology, the *Dharmasindhu* comes to the conclusion that the water that enters into the vessel has the volume of one *prastha* which is equal to sixteen (*ṣoḍaśa*) *palas.* Recall Śrīpati's view that the bowl should hold sixty (*ṣaṣṭi*) *palas* of water!

state of [their] becoming a married couple (*dampatyoḥ bhāvāya*), you be the means of measuring time.'

With this sacred formula, preceded by the worship of Gaṇeśa and Varuṇa, the bowl should be placed [on the water in the basin]. If the bowl thus placed moves to the south-east, south, south-west, or north-west of the basin, it is not auspicious. If it stays in the middle, or moves to other directions, it is auspicious. Likewise, if it fills [and sinks] in the five directions starting from the south-east, it is not auspicious. Thus the discussion of the water clock.

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