

MISCELLANEOUS COMMUNICATIONS

THE KATAPAYADI NOTATION OF THE SECOND ĀRYA-SIDDHANTA

In my note on the Kaṭapayādi system of expressing numbers, given in this Journal, 1911. 788 ff., I said incidentally, on the authority of statements made by two or three writers which, I now find, are not sufficiently explicit, that this system is used in the astronomical work which is known as the Second Ārya-Siddhānta. I have recently obtained a copy of this work as edited by Mahamahopadhyaya Sudhakara Dvivedi.¹ I find that the work certainly does use a Kaṭapayādi notation. But its system differs markedly from that one, described by me, which is taught by the Paribhāṣhā verse *Na-ñāv=achaś=cha*, etc., and is illustrated by the examples given by me. Also, the work does not confine itself to the Kaṭapayādi notation: see, for instance, p. 172 ff., verses 92-7, where it uses the system of numerical words.

The Kaṭapayādi system used in the Second Ārya-Siddhānta, is defined in chapter 1, verse 2, as follows:—

Rūpāt-kaṭapaya-pūrvā
varṇā varṇa-kramād=bhavanty=aṅkāḥ |
ñnau sūnyam̐ pratham-ārthē
ā chhēdē ai tritīy-ārthē ||

This tells us that the rows of letters *k* to *ñ*, *ṭ* to *n*, *p* to *m*, and *y* to *h* or *l*, are numbers; each row running from *rūpa*, 'an exemplar or single specimen', which means 'one': also, that *ñ* and *n* are ciphers. To this extent, this system is identical with the one already

¹ Under the title "Mahā-Siddhānta, a Treatise on Astronomy by Āryabhata"; Benares, 1910.

described by me: see the table on p. 791. In other respects this work presents a different system, which, so far as I know, has not yet been found used anywhere else.

The first important difference between the two systems is as follows. The system as taught by the verse *Na-ñāv*, etc., is subject to the rule *Añkānām vāmatō gatih*, which means that the numbers must be stated with the lowest figure, the unit, first, on the left, but are to be applied in the opposite direction, with the unit on the right: for instance, in a case quoted by me on p. 790 we have *dē(8)-ha(8)-vyā(1)-pya(1)*, which means 1188. But the rule *Añkānām*, etc., does not apply to the system as taught by the verse *Rūpāt*, etc. In accordance with the usual custom of the southern languages, Tamil, Telugu, and Kanarese, and, I presume, Malayalam and Tulu, the numbers are stated with the highest figure first, and are to be applied in that same direction. Thus, to take a simple instance of a small number, in chapter 1, verse 10, the revolutions of the apogee of the sun in the Kalpa are given by *ghu(4)-ta(6)-pā(1)h*: in the system previously described, this would mean 164: in the present system it means, just as it is stated, 461.

Another important difference is this. In the system taught by the verse *Na-ñāv*, etc., in conjunct consonants only the last member of the combination has value: for instance, in the expression *dēha-vyāpya* quoted just above, the *v* and *p* have no values. But in the system taught by the verse *Rūpāt*, etc., every consonant has value: thus, in this system the same word would have to be taken as *dē(8)-ha(8)-v(4)-yā(1)-p(1)-ya(1)*, and would give, not 1188, but 884,111. Conjunct consonants are not found very freely in the Second Ārya-Siddhānta: but they do occur: in chapter 1, verse 6, we have *knā = 10*; in verse 10, *tsa = 67*; in verse 15, *ska = 71*; in verse 16, *kbha = 14*; and in verse 21, *pra = 12*.

In the system taught by the verse *Na-ñāv*, etc., initial vowels are ciphers. The verse *Rūpāt*, etc., says nothing about initial vowels: for the simple reason that they do not enter into its system at all. In both systems, other vowels have no significance; only the consonants give numbers: thus, *ka*, *kā*, *ki*, *kī*, etc., to *kau*, all mean 1; *kha*, *khā*, *khi*, *khī*, etc., to *kharu*, all mean 2.

The last part of the verse *Rūpāt*, etc., tells us that, in the separation of the words giving numbers, the nominative plural masculine is to be treated as ending in *ā*, and the instrumental as ending in *ai*; so as to avoid a possibly resulting *ś*, *sh*, *s*, or *r*.¹ This may be illustrated by the instance given by the editor in his comments on the verse: we can denote 123 by *kakhagāh*, and 660 by *tatanāh*: but if we want to express "123 × 660", we must take *kakhagā tatanai guṇitāh*; because, if we take, grammatically, *kakhagās tatanair guṇitāh*, this would give "1237 × 6602".²

In the Second Ārya-Siddhānta I do not find any tendency to use the Kaṭapayādi notation, as it was used elsewhere, in the shape of words having particular meanings; much less by devising sentences such as the *Khagō=ntyān=Mēsham=āpa* which I quoted on p. 789.

I mentioned (p. 789, note 2) that Bentley said that the

¹ Any use of the nomin. plural neuter and the instr. singular is of course barred; because the final *ni* and *na* would always give a not wanted cipher.

² The text has been edited for the most part on these lines. But it seems questionable whether the author wrote on them, and whether the manuscripts follow them. The word *chhēdē* in the Paribhāshā verse seems to imply that the full grammatical forms were to be used, and that it was only in analysing the text that the finals in question were to be rejected. The editor has notified no fewer than ten errata in his treatment of the nominative in chapter I, verses 7, 8, 10, 11, where he has given it as ending in *āh*, and three errata in respect of his treatment of the instrumental in verses 24, 27, where he has given it as ending in *aiḥ*: and this is suggestive that the manuscripts have the full grammatical forms, and the editor started by following the manuscripts, and then deviated from them in this detail.

Second Ārya-Siddhanta is dated in its first chapter in the Kaliyuga year 4423 (expired), in A.D. 1322, but Sh. B. Dikshit said that its date is not given. I cannot find in the text before me any support for Bentley's statement, which would seem, therefore, to have been based either on some interpolated verse, or on a misinterpretation of some numerical expression which I cannot identify. On the other hand, chapter 2 gives an abstract account of a second work, the Parāśara-Siddhānta : and here verse 2 says, by way of giving a venerable antiquity and authority to the two Siddhāntas, that they were written :— Īshad-yātē Kalau yugē ; “ when only a small part of the Kali age had elapsed.”¹ There are no clear reasons for following Sh. B. Dikshit in placing the work quite so early as A.D. 950 : but there certainly are grounds for believing that it was known to Bhāskarāchārya, who wrote in A.D. 1150.

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THE YOJANA AND THE PARASANG

Since writing my note given at p. 229 ff. above, I have found that the subject of the *yōjana* has been treated in the *Journal Asiatique*, Sept.-Oct., 1911, p. 375 ff. M. J.-A. Decourdemanche, dealing with the long *yōjana* of 32,000 *hasta* or cubits, has presented there the conclusion that it was equal to two old Persian itinerary *parasangs* each of 7670·40 metres, and its value was 15,340·80 metres, = 9·53231½ miles.²

It may well be the case that there were close relations between the ancient Hīndū and Persian measures ; and even though the subdivisions of the *parasang* do not answer to those of the *yōjana*, that the short *yōjana*

¹ In the other Kaṭapayādi system the expression *īshad-yātē* would mean 6160 : in this one it might perhaps be interpreted as meaning 6816 : but we are still only in the year 5013.

² I use 39·37 inches as the sufficiently close value of the metre.