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"It will flourish, if naturalists, chemists, antiquaries, philologers, and men of science in different parts of *Asia*, will commit their observations to writing, and send them to the Asiatic Society at Calcutta. It will languish, if such communications shall be long intermitted; and it will die away, if they shall entirely cease." SIR WM. JONES.

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No.	Tribe.	No.	Division.	No.	Section.	Subdivision.	No.	Subsection.
III.	KA'KAR.	1	LOWE' KA'KAR	1	KHWAIDA'D-ZAI.			
				2	MURSIA'NGZAI.			
				3	AKTARZAI.			
				4	AWAZAI.			
				5	MEHTARZAI.			
				6	SURGARAI.			
				7	JALAGAI.			
				8	MU'SA KHEL			
				9	KABI'ZAI.			
				10	BA'RAKZAI.			
		2	KUCHNAI KA'KAR.	11	SULIMA'N KHEL.		1	TRAGARAI.
				12	AMAND KHEL or SIMAN-THA or SANATI'A.			
				13	MEHTARZAI.			
				14	PA'NIZAI.		1	ADIZAI.
				15	BA'ZAI.			
				16	SHAMOZAI.			
				17	SURGARAI.			
				18	MALAGAI.			
				19	I'SA' KHEL.			
				20	SARA'NGZAI.		1	MULA'ZAI.
							2	TA'RA'N.
				21	ZAKHPE'L.		1	AMAKAI.
							2	KANOZAI.
							3	NAOZAI.
				22	DUMAR.			
				23	UTMA'N KHEL.			
				24	SANDAR KHEL.		1	A'LI'ZAI.
							2	SHABOZAI.
							3	MÚR.
							4	DARGAI.
							5	WAHA'R.
							6	TENIZAI.
							7	KAYANI.
IV.	LU'NI KHEL.	1	HAMZAZAI.					
		2	SARA'GI.					
V.	ZARKHA'N.							

Tribes of doubtful Afghán descent.

I. SAYAD.	1	GANGALZAI.
	2	BAGARZAI.
	3	AJABZAI.
	4	SHA'DIZAI.
	5	BRAHAMZAI.
	6	HAIDARZAI.
	7	YA'SINGZAI.
	8	URUMZAI.
II. KARBELA.		

(To be continued).

On the Súryaprajñapti.—*By* DR. G. THIBAUT, *Principal, Benares College.*

PART I.

Until recent times our knowledge of the cosmological and astronomical system of the Jainas was very limited and founded not on an independent investigation of the original Jaina literature, but only on the occasional references made to Jaina doctrines by the orthodox Hindu writers on astronomy. For a long time the short account of the subject given by Colebrooke in his "Observations on the sect of the Jainas" (Asiatic Researches, 1807; Essays, Vol. II), remained the only one, and although accurate as far as it goes, it is very insufficient since it chiefly refers to the one doctrine of the Jainas only, which has at all times struck outsiders as peculiarly strange and absurd, *viz.*, the assertion that there exist two suns, two moons and a double set of constellations. This is indeed the doctrine by which the system of the Jainas could most easily be distinguished from similar old Indian systems, and it is consequently referred to and controverted with preference in the Siddhántas. The best known passage from the latter is the one quoted by Colebrooke from Bháskara's Siddhánta-S'iromaṇi. "The naked sectaries and the rest affirm that two suns, two moons and two sets of stars appear alternately; against them I allege this reasoning. How absurd is the notion which you have formed of duplicate suns, moons and stars, when you see the revolution of the polar fish."

This passage of Bháskara's is manifestly founded on a passage found in Brahmagupta's Sphuṭa-Siddhánta where we read in the so-called Dúshaṇádhyáya:

भानि चतुः पञ्चाशत् द्वौ द्वावर्कोदयौ जिनोक्तं यत्।
ध्रुवमत्स्यस्यावर्त्तो भवति यतोऽह्ना ततस्तदसत्॥

o

"There are fifty-four nakshatras, two risings of the sun; this which has been taught by Jina is untrue, since the revolution of the polar fish takes place within one day."

And a passage to the same effect occurs in the 13th adhyáya of Varáha Mihira's Pañchasiddhántiká.

In 1868 Professor A. Weber, to whom we are indebted for our first acquaintance with so many works of Indian literature, published in the tenth volume of the "Indische Studien" a paper on the Súryaprajñapti, being apparently the most important astronomical book whose authority the Jainas acknowledge, and it then appeared that the doctrine of the existence of two suns, moons, etc. constitutes only one feature of a comprehensive system which on the whole is much less fantastical than might have been expected and which, fantastical or not, shows intimate relations to the astronomical and cosmological views which appear to have prevailed all over India before Greek science began to influence the East. Especially it appeared—as pointed out by Professor Weber—that the doctrine propounded in the Súryaprajñapti shows in many points an unmistakable resemblance with that contained in the Jyotisha-Vedáñga the presumably oldest specimen of Indian astronomical literature, and it thus became manifest that the astronomical books of the Jainas do not only furnish information about the opinions held by a limited religious sect, but may, if rightly interrogated, yield valuable material for the general history of Indian ideas. The writer of the present paper has therefore thought it worth while to submit the Súryaprajñapti to a renewed detailed investigation, whereby we should be enabled rightly to esteem its position in the astronomical literature of India, clearly to conceive the peculiar features distinguishing the astronomical system of the Jainas from other systems, and on the other hand to point out what the Jaina system has in common with other systems, and in what way therefore it may be employed for the elucidation of the latter. Professor Weber's paper gives in the main only a short summary of the contents of each chapter of the Súryaprajñapti, following the order of the chapters as found in the work itself and omitting none of them. This was of course the right plan to adopt in a paper giving the first account of a hitherto unknown book. In the present paper it has on the other hand been preferred to give a connected account of the chief doctrines only which are found in the Súryaprajñapti, to combine hints found in the various parts of the work wherever this appeared necessary for the sake of greater clearness, and again altogether to omit relatively unimportant matter. It must be stated at the outset that this paper—like that of Professor Weber—is based more on Malayagiri's commentary on the Súryaprajñapti than on the text of the latter work itself; which apparently anomalous proceeding finds its explanation in the fact of the Manuscripts of the Súryaprajñapti, commonly met with, containing the commentary only *in extenso*, while as a rule only the first words of the passages commented on are given. As it, however, appears that the commentary faithfully follows the text, and as on the other hand the latter, devoid of a commentary, would be hardly intelligible, the absence of a complete text of the Súryaprajñapti is less inconvenient that might at first be assumed. At any rate we may obtain at present a sufficiently full and accurate knowledge of the contents of the book; and in works of the class to which it belongs the interest attaching to the form is a comparatively small one. As already stated, the present paper is by no means intended as an exhaustive review of the contents of the Súryaprajñapti; it is rather meant as an introduction to a complete edition of the work itself which, on account of the various old materials it contains, well deserves to be published *in extenso*. And an introduction of this kind could not well be missed, even if we possessed a complete edition or translation of the book, as the reader of the text of the work or of a literal translation of the text would find it by no means an easy task unaided to reconstrue the leading features of the system.

The Súryaprajñapti is written in Jaina-prákṛit, and divided into twenty books called prábhṛitas, some of these again into chapters, called prábhṛita-prábhṛitas. The arrangement of the matter treated of is by no means systematical, and the text, still more the commentary are full of tedious reiterations. Malayagiri, the commentator, has done his work most conscientiously; too conscientiously, the reader afflicted by his extraordinary diffuseness often feels tempted to say. Especially he delights in illustrating the numerical rules given in the text by at least half a dozen examples, where one would have sufficed, dwelling with evident complacency on each step even of the simplest calculation. But his comments are very perspicuous and certainly deserve to be extracted, although not to be reproduced *in extenso*.

Proceeding now to our proposed task, let us dispose at the outset of the distinctive doctrine of the Jainas according to which there are two different suns, two moons and two sets of constellations. When inquiring into the origin of this certainly peculiar notion, we are led to a very simple reason, an impartial consideration of which makes the Jaina system appear much less fantastical and arbitrary than we at first are inclined to think. This reason has already been pointed out by Colebrooke, Asiatic Researches, Vol. IX, p. 321, where he says "They (the Jainas) conceive the setting and rising of stars and planets to be caused by the Mountain Sumeru and suppose three times the period of a planet's appearance to be requisite for it to pass round Sumeru and return to the place where it emerges. Accordingly they allot two suns, as many moons, and an equal number of each planet, star and constellation to Jambudvípa; and imagine that these appear on alter-

nate days south and north of Meru." These words scarcely require anything added to be to them in the way of comment. The Jainas hold (as will be seen in detail further on) the old Indian idea of sun, moon and stars revolving round Mount Meru. To anybody holding this opinion, the question must have suggested itself "In what time is one such complete revolution performed?" The prevailing opinion, represented for instance by the Puráṇas, was that the whole revolution is performed in twenty-four hours, so that the sun describes during the time when it is day in Bharatavarsha the southern half of his circle, and during the time when it is night to the south of Mount Meru, and day in the countries north of it, the northern half. The Jainas, however, took a different view of the matter. To them it seems to have appeared more appropriate that as there are four directions—south, west, north and east—the sun's circle should be divided into four quarters corresponding to the four directions, and that he should bring day in succession to the countries to the south, west, north and east of Meru But then, as it must be supposed that his passing through each of the four quarters occupies the same time, how can it come about that he again appears to rise to the Bharatavarsha after the lapse of a period only sufficient to advance his place by one quarter of the circle? Out of this difficulty the Jainas extricated themselves by simply assuming that the sun rising on a certain morning is not the same sun which had set on the preceding evening, but a second sun similar in every way to the first one. The whole circle is thus described by two suns separated from each other by half the circumference, each of which appears in the Bharatavarsha on alternate days. The same reasoning lead to the assumption of two moons and two sets of stars.

Great as appears to be the difference produced by this hypothesis between the system of the Jainas and the commonly received opinions, it practically is of very small importance and may—as will be done in the following—as a rule be left altogether out of account whenever we have to consider the motions of sun and moon. When for instance the sun having started from Aśviní has passed through the twenty-eight nakshatras, he enters, according to the generally received opinion, again into the same nakshatra Aśviní, according to the Jaina opinion into a second nakshatra called Aśviní too; but as this second nakshatra has the same name, the same extent, and the same relative position as its namesake, as like the latter it is preceded by Revatí and followed by Bharaṇí, and as at the same time when the sun has entered into the second Aśviní, another sun the exact and indistinguishable counterpart of the former one has entered into the former Aśviní, it is clear that we may, when speaking of the motion of the heavenly bodies, save ourselves the trouble of continually referring to two suns, two moons and two sets of nakshatras and, remembering that there are two of each kind, express ourselves as if there were only one. To proceed.

The astronomic-chronological period on which the system of the Súryaprajñapti is based, is the well-known quinquennial yuga or cycle with which we have long been acquainted from the Jyotisha Vedáñga. The same cycle is described in the Garga Saṃhitá as we see from the extant fragments of the latter work, and we learn from Varáha Mihira's Pañchasiddhántiká that it likewise formed the fundamental doctrine of a Paitámaha Siddhánta which, according to Varáha Mihira's judgment, was one of the more important Siddhántas known at his time. It is alluded to and rejected in a few words by Brahmagupta in the dúshaṇádhyáya of the Sphuṭa Brahma-siddhánta. References to this cycle are met with in the early history of Buddhism. Whether the so-called Vedic literature is acquainted with a cycle of this nature is doubtful.* It will not be necessary to dwell in this place at length on the constitution of the yuga; it will suffice to state that it is based on the assumption of five sidereal revolutions of the sun being exactly equal in duration to sixty-seven periodical revolutions of the moon and to sixty-two synodical months, while one complete revolution of the sun is supposed to be performed in three hundred and sixty-six days. That a cycle of this nature based as it is on an utterly wrong assumption could maintain itself for a considerable time as it manifestly has done is a matter for legitimate wonder, and does not find a parallel in the history of chronological systems among any other civilized nation. At the end of one yuga already the quantity of the error induced by the mistaken estimation of the length of the solar year amounts to nearly $5 \times \frac{3}{4} = 3\frac{3}{4}$ days, the accumulation of which quantity after the lapse of a few yugas could not escape the attention, we should think, of even the most careless observers. The matter would indeed lie altogether differently if a conjecture (or as it stands we might almost say, an assertion) of Colebrooke referring to this point had been verified. He—after having given an account of the manner in which the Jyotisha-Vedánga manages to maintain harmony between civil and lunar time—continues "and thus the cycle of five years consists of 1860 lunar days or 1830 nycthemera, subject to a further correction, for the excess of nearly four days above the true sidereal year: but the exact quantity of this correction and the method of making it, according to this calendar, have not yet been sufficiently investigated to be here stated." The fact is that of this correction which Colebrooke considered so indispensable, that he speaks of it as being actually found in the Vedánga, no

* The question referred to in the text cannot be discussed here. The writer hopes shortly to find an occasion fully to treat it elsewhere.

traces are to be found either in the Vedánga itself or—and this is of great importance as the Vedánga is still partially unexplained—in the Súryaprajñapti which illustrates the constitution of the quinquennial yuga in the most diffuse manner, but has nothing to say about a correction of the kind mentioned.—The subdivisions of the yuga are in the Súryaprajñapti described with great fulness; what is really essential admits, however, of being stated in a few words. Each solar year is divided into two ayanas of one hundred and eighty-three days each. Each ayana in its turn comprises six solar months, each of which lasts $30\frac{1}{2}$ days. Two of these solar months constitute a solar season; the reckoning of the seasons starts, however, not from the beginning of the yuga, but the latter is made to mark the middle of a season, so that the rainy season which counts as the first begins a month before the beginning of the yuga. Again the yuga comprises five years of 360 days each, each year in its turn being divided into twelve months of 30 days each; in the Súryaprajñapti this kind of year—commonly known as the sávana year—is called the *karma-year* or *ṛitu-year* which latter name would more properly be given to the solar year. The six days by which this year is shorter than the solar year are called atirátras. Again the yuga comprises sixty-two synodical months, the first of whom begins with the moon being full in the first point of Abhijit. Each of these months is divided into a light and a dark half; each half comprises fifteen tithis or lunar days of equal duration. Sixty-two of these months being equal in duration to sixty-one karma-months of 30 days each, it follows that sixty-two tithis are equal to sixty-one natural days; in order therefore to maintain harmony between the numbers of the natural days and those of the tithis, a break in the counting of the tithis is made whenever two tithis terminate during one natural day, *i. e.*, according to the Súryaprajñapti on the occurrence of each sixty-second tithi. The details of this process are not stated in the Súryaprajñapti, but there can be no doubt that *mutatis mutandis* it was managed as it has been managed in India ever since. To give an example, the sixtieth natural day, counting from the beginning of the yuga, during which the sixtieth tithi terminated was counted as pañchadaśí (fifteenth tithi), the next following day as pratipad (first day of the new lunar half month) and then the day after that not as dvitíyá, second lunar day, but as ṭritíyá third lunar day, the second lunar day having already terminated together with the preceding sixty-first natural day. These sixty-two lunar months are divided among five lunar years, the first, second and fourth of which comprise twelve lunations each, while the third and fifth count thirteen each. The technical name of years of the latter kind is abhivardhita-saṃvatsara, the increased year. The method according to which the two thirteenth months are intercalated in the yuga is

not described in detail; it is however clear enough how it proceeded. The thirty-first lunation and again the sixty-second one were not counted, but formed together with the month immediately following a kind of double month taking its name from the second constituting member. Thus there is nominally no thirteenth month, and a proper name for the latter is therefore not required.

Again the yuga consists of sixty-seven periodical lunar months, the moon during it returning sixty-seven times to the place from which she had started at the beginning. No attempt is made in the Súryaprajñapti to group these months into years nor are they subdivided into days of equal duration; they are simply said to comprise $27\frac{21}{67}$ days each. They are, however, subdivided into two ayanas each, analogously to the division of the solar year into ayanas. This division is indeed legitimate enough as it is based on the alternate progress of the moon towards the north and south, about which details will be given later on. Less comprehensible is on the other hand the division of each periodical month into six lunar seasons, whose names answer to those of the solar seasons beginning with the rainy season; a division of this kind is of course utterly gratuitous and purposeless, and to us interesting only as a specimen of the Indian's excessive tendency to systematize.

If we now proceed to an examination of the account given in the Súryaprajñapti of the revolutions of sun and moon, we find at the outset that it differs from the statements made by Garga and in the Vedánga in one important point. According to the latter authorities (see Jyotisha-Vedánga, v. 6; this Journal for 1877, p. 415; Weber, Nakshatras II, pp. 28, 33), the yuga begins with the winter solstice, at the moment when it is new-moon, sun and moon being in conjunction in the beginning of the nakshatra Dhanishṭhá; according to the Súryaprajñapti the yuga begins with the summer solstice, at the moment when the moon is full in the beginning of Abhijit and the sun consequently stands in Pushya. The coincidence of the winter solstice with new moon marking, according to the Vedánga, the beginning of the yuga may of course actually have taken place at the time when the doctrine of the quinquennial yuga was first established and will have recurred later on from time to time; but it is evident that it could not regularly recur every fifth year. To this fact, however, as well as to the change which in consequence of the precession of the equinoxes gradually took place in the position of the sun at the time of the winter solstice, the eyes of the Hindus seem to have remained shut during a considerable period. Now it is curious to see that in this one point at least the author of the Súryaprajñapti who, on the whole, faithfully adheres to the old system and does not hesitate to take over the quinquennial yuga itself with all its glaring imperfections, considered himself entitled or

obliged to deviate from the received tradition. For once the testimony of the eyes was placed above old authorities. In the first place, the winter solstice had so far receded from the beginning of Dhanishṭhá that the change could not be ignored; in the second place, it must have so happened that at the time of the author of the Súryaprajñapti no new moon took place together with the winter solstice, while—as we may presume—some full moon happened to coincide or nearly to coincide with some summer solstice. Accordingly the beginning of the yuga was changed. Faute de mieux the summer solstice coinciding with full moon was taken as the new starting-point, and the sun's place at the time was removed from the middle of Áśleshá which it had occupied in the old system to a point in Pushya. The moon's place at the time of the summer solstice, being separated from the sun's place by half the circumference, is then at the beginning of Abhijit; the latter point marks at the same time the sun's place at the time of the winter solstice.

The account given in the Súryaprajñapti of the position of the sun at the two solstices enables us to enter into a consideration of the approximate time at which either the work itself or some older work on which it may have been based was composed. The expression "approximate" is used on purpose as the general difficulties besetting an estimation of this kind referring to Indian astronomical works are well known, and as in our case special difficulties arise in addition to them. As will be seen later on, the Súryaprajñapti throughout employs twenty-eight nakshatras of unequal extent, while the Vedánga as well as the bulk of the later astronomical literature make use of twenty-seven nakshatras of equal extent. The relation of these two systems to each other necessitates a short excursus, for the starting-point of which we take a passage in Bháskara's Siddhánta Siromaṇi (Grahagaṇita, Spashṭádhikára, 71-74, p. 93 of Bápu Deva's edition) and a parallel passage from Brahmagupta's Sphuṭa-siddhánta. The former of the two, translated, runs as follows:

"This method of finding the Nakshatras which has thus been taught in a rough manner by the astronomers for the purposes of common life, I shall now teach in an accurate form as it has been proclaimed by the ṛishis for the purpose of processions, marriages, etc. The experts have declared six (nakshatras) to have one portion and a half, *viz.*, Viśákhá, Punarvasu and the (four) nakshatras called dhruva; six to have half a portion, *viz.*, the constellations presided over by the Sarpas, Rudra, Váyu, Yama, Indra, Varuṇa; the remaining fifteen to have one portion each. The portion of one nakshatra is called the mean motion of the moon (during one ahorátra). The minutes of the circle lessened by the portions of all (the 27 mentioned) nakshatras are the portion of Abhijit, lying beyond the nakshatra of the Viśve Devas, etc." These statements are repeated in Bháskara's own

commentary, the Vásaná, where the common names of the nakshatras (Viśákhá, Punarvasu, Rohiṇí, the three Uttaras;—Áśleshá, Árdrá, Svátí, Bharaṇí, Jyeshṭhá, Śatabhishaj) are given and where Puliśa, Vasishṭha, Garga and others are said to be the Ṛishis alluded to in the text. The rough mode of computation referred to in the beginning of the above quotation is the one contained in v. 67 of the same chapter and agrees with the rule given in the Súrya Siddhánta, II, 64. According to it, when we wish to find the place of sun or moon or one of the planets in the circle of the nakshatras, we have to divide the longitude of the heavenly body expressed in minutes by 800; the quotient then shows the number of nakshatras through which the planet has already passed, and the remainder the traversed part of the nakshatra in which it is at the time. This rule therefore bases on the assumption of twenty-seven nakshatras each of which extends over one twenty-seventh part of the circle. Now, according to Bháskara, the Ṛishis taught that whenever greater accuracy is required, the nakshatras have to be considered as being of unequal extent. In the first place only fifteen of them are to be regarded as having the average extent, while six exceed that amount by one half and six others remain below it by one half; and in the second place the twenty-seven nakshatras are no longer to occupy the whole circle, but only that part of it which corresponds to twenty-seven times the mean daily motion of the moon, while the remaining part of the circle is assigned to a twenty-eighth nakshatra Abhijit. Bháskara's statements are manifestly founded on a passage met with in the 14th chapter of the Sphuṭa Brahmasiddhánta which gives the same details regarding the different extent of the nakshatras, and is introduced by the following verse—

पौलिशरोमकवासिष्ठसौरपैतामहेषु यत्प्रोक्तम् ।
तन्नक्षत्रानयनं नार्यभटोक्तं तदुक्तिरतः ॥

"The calculation of the nakshatras, which has been taught in the Pauliśa, Romaka, Vásishṭha, Saura, Paitámaha Siddhántas, is not mentioned by Áryabhaṭa; I therefore proceed to explain it."

And later on—

अध्यर्धादिक्षेत्राणि संहितास्वभिहितानि गर्गाद्यैः ।
यस्माद्बहूनि तस्मान्नार्यभटोक्तं तदानयनम् ॥

The explicit statement about number and extent of the nakshatras in the older period of Indian astronomy, which is contained in the two passages quoted from Brahmagupta and Bháskara, is of considerable interest. If the account given by these two writers is correct and there is no reason to doubt of that, it appears in the first place that the mere circumstance of only twenty-seven nakshatras being mentioned in some detached fragment of an astronomical work which we do not possess in its entirety,

would not justify the conclusion of the author of the work having been acquainted with twenty-seven nakshatras only. Nay, even the author of a treatise like the Vedánga who throughout speaks of 27 nakshatras only may have done this simply because he meant his work to be an elementary one, unencumbered by the assumption of 28 nakshatras of unequal extent. In the second place the distinct statement that the old writers on astronomy made use of Abhijit solely when greater accuracy was aimed at, and that they then made its extent to correspond to the excess of a sidereal month above twenty-seven days, certainly seems to point to the conclusion that the introduction of Abhijit into the circle of the nakshatras was an afterthought, consequent on the improved knowledge of the length of the moon's periodical revolution. With regard to the books in which, according to Bháskara and Brahmagupta, the division of the sphere into 28 nakshatras of unequal extent was taught in addition to the simpler division into 27 equal nakshatras, we have to remark that the Súrya-siddhánta known to us contains no such statement; the Saura-siddhánta of Brahmagupta may have been a different work. We are unable to control the statement with regard to the Romaka, Paulisa, Vásishṭha-Siddhántas. Of Garga, however, we know from quotations several passages bearing on the point in question: in the first place, the passage quoted by Bhaṭṭotpala (in his commentary an Varáha Mihira's Bṛihatsaṃhitá, IV, 7; see Weber, Nakshatras, I, p. 309), which corroborates Bháskara's statement regarding the different extent of the Nakshatras, is, however, silent about Abhijit. As the passage stands, it would lead us to infer that Garga divided the whole circle into twenty-seven parts, the extent of fifteen of which is equal to one, of six to one half and of six to one and a half. The quotation may, however, be incomplete, and at any rate we have Brahmagupta's and Bháskara's word for Abhijit having been acknowledged by Garga too. However this may be, that Garga, as a rule, introduced into his calculations neither Abhijit nor the inequality of the extent of the twenty-seven nakshatras, appears from the places which he assigns to the sun at the two solstices, *viz.*, at the beginning of Dhanishṭhá and the middle of Áśleshá; for if we calculate the place of the summer solstice by starting from the beginning of Dhanishṭhá and making use of the unequal extent of the nakshatras, we obtain as place of the summer solstice not the middle of Áśleshá but rather the end of it or the beginning of Maghá.

To return. The special difficulty by which we are met when attempting to compare the places assigned to the solstices in the Súryaprajñapti with the places which they occupy according to Garga and the Vedánga on one hand and the Siddhántas on the other hand, lies in the circumstance of our not knowing exactly how the two divisions of the sphere—the one into 27 nakshatras of equal extent, the other into 28 of unequal extent—were made to correspond with each other. If we suppose—and this seems the most likely supposition—that each of the 27 nakshatras was curtailed by the twenty-seventh part of the small portion assigned to Abhijit and that the reckoning started from the beginning of Abhijit, (which according to the system of the Súryaprajñapti is the first of the series, as at the beginning of the yuga it is in conjunction with the moon), we may hazard an hypothesis with regard to the time lying between the Vedánga and the Súryaprajñapti, or rather between the observations of the solstices recorded in the two works. According to the Vedánga the winter solstice takes place in the beginning of Dhanishṭhá, according to the Súryaprajñapti in the beginning of Abhijit (which is the place of the full moon on the day of the summer solstice at the beginning of the yuga, and consequently the place of the sun on the day of the winter solstice); the two places are therefore separated by the whole of Śravaṇa and Abhijit. Having, according to the hypothesis stated above, reduced the extent of Śravaṇa (= 13·°33) by the 27th part of the extent of Abhijit, which extent is equal to about 4·°12, we obtain for Śravaṇa 13·°18; to this we add Abhijit = 4·°12; the sum *viz.*, 17·°3 indicates the extent of the displacement of the solstice during the intervening period. Allowing seventy-two years for 1° of precession, the length of this period would be about 1246 years. If we therefore knew the absolute date of the Vedánga we might state the approximate absolute date of the observation recorded in the Súryaprajñapti, on the supposition always of the manner in which the two divisions of the sphere have been adjusted to each other being the right one. But, as Professor Whitney has shown, it is scarcely possible to form any satisfactory conclusion with regard to the date of the Vedánga, and we therefore abstain from giving a positive opinion about the date of the Súryaprajñapti.

We now proceed to a detailed consideration of the hypothesis by which the author of the Súryaprajñapti tries to account for the appearances presented by the various motions of the heavenly bodies, beginning with the sun.

The three different motions of the sun which he endeavours to explain are firstly, the daily motion in consequence of which the sun seems to approach us from the East, passes through our field of vision and finally disappears in the West; secondly, the annual motion in consequence of which the sun seems to pass in the course of a year through the circle of the nakshatras, proceeding from the West towards the East; and thirdly the motion in declension according to which the sun ascends towards the north during one half of the year and descends towards the south during the other half. As in all systems which consider the daily motion of the sun to be real (not an appearance produced by the revolution of the earth

round its axis), the annual motion of the sun through the circle of the nakshatras is said to be apparent only, and produced by the circumstance of the motion of the sun being somewhat slower than that of the nakshatras, so that he daily lags behind by a certain quantity which accumulated during a whole year amounts to an entire revolution. How the Súryaprajñapti supposes the first and third motions to take place will appear from the following.

It must be remembered at the outset that the general conception of the configuration of the world which we find in the Súryaprajñapti is the same as that known from the Puráṇas. The earth is considered to be an immense circular flat consisting of a number of concentric rings, called dvípas, separated from each other by ring-shaped oceans. In the centre of the earth stands Mount Meru; around it runs the first dvípa—Jambudvípa, the only one which will concern us in the following. It is surrounded by a circular ocean, the water of which is salt (the lavaṇa-samudra). The southern segment of the Jambudvípa is occupied by the Bháratavarsha, the northern segment by the Airávata-varsha; east and west of Mount Meru are the two portions of the Videha-varsha. Sun, moon and stars revolve round Mount Meru, in circles of different height above the Jambudvípa, the same heavenly body, however, always keeping the same height. The detailed features of these motions are now according to the Súryaprajñapti as follows.

The circumstance of the sun seeming during one half of the year to approach daily more and more the north, while during the other half he seems to descend towards the south is explained in the following manner. On the longest day of the year which at the beginning of the cycle coincides with the first day of the lunar month S'rávaṇa, the sun describes round the mountain Meru a circle, the diameter of which is 99,640 yojanas. The distance of the sun from the centre of Meru amounts therefore to 49,820 yojanas. On the next day the sun describes a circle concentric with the first, and having a diameter greater by $5 \frac{35}{61}$ yojánas, so that the distance of the sun, from Mount Meru now amounts to $49{,}820 + 2 \frac{48}{61}$ yojanas. In the same manner the diameter of the circle described by the sun increases by $5 \frac{35}{61}$ on the third day, fourth day, etc., up to the day of the winter solstice, which according to the system is the 183rd day after the summer solstice. On this day the sun describes round Mount Meru a circle, the diameter of which is equal to 100,660 yojanas, so that his distance from Mount Meru amounts to 50,330 yojanas. Beginning from this day the solar circles contract again, by the same quantity daily by which they had expanded during the southern progress of the sun. During the 182 days intervening between the day of the winter solstice and the day of the following summer solstice the sun describes again the same 182 circles in which he had descended towards the south, only in reverse order, until, on the day of the second summer solstice, he has again reached the innermost circle, from which he had started a year ago. During the second year the same expanding and contracting of the solar circles repeats itself and so on. The fact of the sun seeming to ascend towards the north during one half of the year, while he seems to descend towards the south during the other half is therefore explained by the supposition that he approaches us during the former half, while he recedes from us during the latter half. The system does not assume that he actually ascends or descends; for all the circles described by him are at an equal height above the Jambudvípa; he only appears to us to stand lower at the winter solstice than he does at the summer solstice, because at the former period he has receded from us to the amount of five hundred and fifty yojanas. The exact localities too above which the sun describes his daily circles are defined. The innermost circle, *i. e.*, the circle nearest to Mount Meru, which the sun describes on the longest day, would, when projected upon the earth, be distant 180 yojanas from the outer margin of the Jambudvípa. The second circle approaches nearer to that margin, the third still nearer, and so on, until the circles of the sun are no longer above the Jambudvípa itself but above the salt ocean, the lavaṇoda, which surrounds the Jambudvípa. Finally on the shortest day of the year the sun describes a circle which, in projection, is distant 330 yojanas from the edge of the Jambudvípa. After that he again approaches the Jambudvípa, and on the next summer solstice he has again entered into it to the amount of 180 yojanas. The technical term by which this recurring progress of the sun towards the Jambudvípa and the salt ocean is denoted in the Súryaprajñápti, is उगाहइ or अवगाहति (-ते); the sun is said to merge himself, or to enter to a certain distance into the Jambudvípa or into the salt ocean accordingly as his circles are vertically above the land or the surrounding sea.

In connexion with the sun's motion in circles of different diameter, the Súryaprajñapti treats of the increase and decrease of the length of the day. As in the Jyotisha-Vedáṅga, the length of the day of the summer solstice is estimated at eighteen muhúrtas, that of the shortest day at twelve muhúrtas. The days between the two solstices are erroneously supposed to decrease or increase by a uniform quantity, which is easily found to be equal to $\frac{6}{183} = \frac{2}{61}$ of a muhúrta.

A number of opinions of other teachers agreeing with the theory stated above in its general features, but differing in the figures, are likewise given by the Súryaprajñapti.

Different opinions regarding the extent of the solar circles are given in I, 8 and, which comes to the same, different opinions about the distance of the two suns from each other in I, 4. According to this chapter there

were six different opinions about the distance of the two suns from each other on the longest day when the sun—or the two suns—describe the innermost and smallest circle. According to some teachers, the distance of the two from each other, or in other words the diameter of the circle they describe amounts to 1,133 yojanas, according to others to 1,134 yojanas; according to others again to 1,135 yojanas. Most probably we have to combine with these statements the statements given in the next chapter (I, 5) regarding the different opinions prevailing on the extent to which the sun "immerges" himself into the Jambudvípa and into the salt ocean. There we read that, according to one opinion the sun moves on the longest day in a circle which projected on the Jambudvípa is distant 1,133 yojanas from the edge of the latter, while on the shortest day he describes a circle above the salt ocean at the distance of 1,133 yojanas from the Jambudvípa. According to the opinions of two other sets of teachers, the number of yojanas in both cases is 1,134 and 1,135. If we combine these measures with the measures of the diameter of the innermost solar circle given above (and the sameness of the figures seems to entitle us to do so, although this is by no means explicitly stated), we get for the diameter of the whole Jambudvípa 1,133 (= diameter of the innermost circle) + 2 × 1,133 (= distance of the innermost circle from the edge of the Jambudvípa on both sides), therefore altogether 3,399 yojanas; or, starting from the numbers 1,134 and 1,135, 3,402 or 3,405 yojanas. These are very moderate dimensions compared with the 100,000 yojanas, which length the author of the Súryaprajñapti himself attributes to the diameter of the Jambudvípa, and we shall not be mistaken in ascribing to opinions of this nature a considerably greater antiquity than to those represented by the Súryaprajñapti. Besides, there is another circumstance in favour of such a view. The Súryaprajñapti throughout makes use of the relation $\sqrt{10} : 1$ for calculating the circumference of a circle. Thus for instance the diameter of the Jambudvípa being 100,000 (yojanas), its circumference is said to amount to 316,227 yojanas 3 gavy. 128 dhan. $13\frac{1}{2}$ añg. But those teachers who stated the diameter of the innermost solar circle to amount to 1,133 or 1,134 or 1,135 yojanas stated at the same time that its circumference amounts to 3,399 or 3,402 or 3,405 yojanas, *i. e.*, they made use of the relation 3 : 1 for calculating the circumference of a circle from its diameter. The adoption of this very rough approximate value seems to point back to a comparatively ancient time.*

* It seems that all Jaina books take $1 : \sqrt{10}$ as expressing the relation of the diameter to the circumference. See for instance Bhagavatí Sútra II, 1. 45 (Weber, p. 264), where, however, some confusion seems to have crept into the figures. The old and simple relation 1 : 3 is found for instance in the Bhúmiparvan contained in the Bhíshmaparvan of the Mahábhárata. There the circumferences of the planets are

Three more opinions concerning the distance of the two suns from each other on the longest day are quoted. According to the first, one whole dvípa with the addition of the surrounding ocean intervenes between the two; according to the second two dvípas and two oceans; according to the third three dvípas and three oceans. The distance in yojanas is not given. Two more opinions concerning the extent to which the sun enters into the Jambudvípa are stated; according to some the sun enters on the longest day into half the Jambudvípa and on the shortest day into half the salt ocean; the distances in yojanas are not mentioned. And according to others the sun enters neither into the Jambudvípa nor into the salt ocean, but moves in the interval (apántarála) of the two; how we have to imagine this interval does not appear.

The eighth chapter of the first book contains a long exposition of the dimensions of the circles described by the sun. Four different dimensions are stated. Instead of simply giving the length of the diameter, the length and breadth (áyáma and vishkambha) are given; these two are of course equal in a circle. Then the circumference of the circle is given, according to the ratio $\sqrt{10} : 1$, and finally the "váhalya," the thickness of the circle, *i. e.*, the diameter of the space filled by the mass of the sun or more simply the diameter of the sun himself. This amounts according to the Súryaprajñapti to $\frac{48}{61}$ of a yojana. The diameter and the circumference of the circles are of course continually changing, the circle described on the longest day having the smallest dimensions and that described on the shortest day having the greatest. The dimensions of the small circle and the amount of the daily increase have been mentioned above; it is therefore not necessary to follow the Commentator into the very tedious calculation of the dimension of each daily circle. The opinions of three other teachers on the dimensions of the circles, according to which the diameter amounts to 1,133 yojanas etc., have already been mentioned; the thickness of the circle, *i. e.*, the diameter of the sun is held by them to amount to one yojana.

We turn now to the statements regarding the velocity with which the sun moves in his different circles, and among these at first to those made by the Súryaprajñapti itself. The calculation is a very simple one. Each daily circle being described by two suns, each of which travels through half of it in thirty muhúrtas, the whole circle is described by one sun in sixty muhúrtas, and consequently we have, in order to find the velocity of the sun, to divide the periphery of the daily circle by sixty; the quotient is the number of yojanas travelled through by the sun in one muhúrta. Thus the sun, when travelling in the smallest innermost circle, the circumference

stated in numbers which are the threefold of the numbers expressing the diameters: चन्द्रमास्तु सहस्राणि राजनेकादश स्मृतः । विष्कम्भेन कुरुश्रेष्ठ त्रयस्त्रिंशत्तु मण्डलम् etc.

of which is 315,089 yojanas long, passes in one muhúrta through 5,251 $\frac{29}{60}$ yojanas. On the following day both suns travel in the second circle which is somewhat larger than the first one, and consequently the suns having to describe a larger space in the same time, *i. e.*, during the duration of a nycthemeron travel somewhat faster, pass in one muhúrta through 5,251 $\frac{47}{67}$ yojanas. Thus day after day the speed of the two suns is increasing in accordance with the continually increasing extent of the diurnal circles, until on the day of the winter solstice both suns travelling in the outmost circle pass through 5,305 $\frac{15}{60}$ yojanas in one muhúrta. Beginning from this day their speed diminishes as they are again approachiug the innermost circle, until on the day of the next summer solstice their rate of speed is again at its minimum. In connexion with this discussion of the swiftness of the sun, the Súryaprajñapti treats of the question of the distance from which the light of the sun becomes visible to the inhabitants of the Bharata-varsha. By this distance we have, however, to understand not the distance of the sun from the Bharata-varsha in a straight line, but rather that part of the sun's daily circle which lies between the point of the sun's rising and the meridian. It is well known, says the Commentator, that the sun becomes visible to the eye of man at a distance equal to half of the extent (kshetra) over which he travels during the whole day, *i. e.*, at the time of his rising, his distance from us (=from our meridian, although this is not expressly stated in the Súryaprajñapti) is half of the arc which he describes during the whole day. The length of this arc has to be measured simply by the time which the sun takes to travel through it. Thus, for instance, on the longest day the sun is visible to the inhabitants of the Bharata-varsha during eighteen muhúrtas out of thirty; from the moment of his rising he will therefore take nine muhúrtas to come up to the point straight in front of us (to the meridian). Now we have seen before that on the longest day the sun travels over 5,251 $\frac{29}{60}$ yojanas in one muhúrta; consequently he travels in nine muhúrtas over 47,263 $\frac{21}{60}$ yojanas. This therefore is the distance—expressed as an arc of the diurnal circle—at which he becomes visible to the eye of man. On the shortest day on the other hand the sun is visible for twelve muhúrtas only; we have therefore to multiply the amount of his motion in one muhúrta by six in order to find the distance at which he first appears to the eye of man on that day.

Regarding the swiftness of the sun four other opinions are recorded by the author of the Súryaprajñapti. According to some teachers, the sun travels in one muhúrta over six thousand yojanas, and as far as it appears this rate of motion is the same in whatever circle the sun is moving. How these teachers accounted for the fact of the sun taking the same time to travel through a large circle as through a small one is not explained. The amount of space illuminated on each day (the tápakshetra), expressed as arc of the diurnal circle of the sun, they calculated in the same manner as the author of the Súryaprajñapti, *viz.*, by multiplying the amount of motion in one muhúrta by the number of the muhúrtas of the day. Thus the tápakshetra on the longest day would amount to 108,000 yojanas, that on the shortest day to 72,000 yojanas. According to the opinions of two other schools, the motion of the sun in one muhúrta amounts to 5,000 yojanas or 4,000 yojanas. Here too nothing is said about any variation in the sun's speed at different times of the year. The tápakshetra is calculated in the manner stated above. The last opinion mentioned is that of some teachers who held the rate of speed of the sun to be different during different periods of the day. According to them, the sun passes over six thousand yojanas in the muhúrta after his rising and in the muhúrta preceding his setting, over four thousand yojanas during the muhúrta in the middle of the day and over five thousand yojanas in all other muhúrtas.

The various opinions prevailing with regard to the rising and setting of the sun are detailed in the first chapter of the second book. The opinion of the author clearly appears from what has already been stated. There is no real sunrise or sunset; the sun or rather the two suns revolving round Mount Meru appear to rise to the inhabitants of some particular place at the moment when they enter their field of vision, and they appear to set when they leave it. In reality they always move above the Jambudvípa at the same height, estimated by the Súryaprajñapti to amount to eight hundred yojanas. At the beginning of the yuga at sunrise on the first of S'rávaṇa the Bhárata sun becomes visible to the Bhárata-varsha having reached the south-east point of his diurnal circle; diametrically opposite to it, *viz.*, in the north-west point of the same circle the Airávata sun appears to rise to the inhabitants of the tracts north of Mount Meru. During the course of this day the Bhárata sun therefore illuminates the countries to the south; the Airávata sun those to the north of Meru. At the time of sunset the Bhárata sun having passed through the southern segment of his circle disappears from the view of the people south of Meru and enters the view of those west of Meru; these latter therefore have their day while it is night in Bhárata-varsha. At the same time the Airávata sun appears to have set to the people north of Meru and to have risen to those east of Meru. On the second day the Bhárata sun rises to the countries north of Meru and the Airávata sun to the Bhárata-varsha. On the third morning the Bhárata sun has completed a full circle and therefore again rises to the Bhárata-varsha while the Airávata sun again rises to the regions north of Meru. And so on *ad infinitum*. We may recall here a parallel passage from the Vishṇupuráṇa (II, 8), tending to illustrate how sunrise and sunset were conceived to take place on the hypothesis of the sun (the Puráṇas

know of one sun only) moving round Meru. "The sun is stationed at all times in the middle of the day (*i. e.*, it is always midday at that place above which the sun is) and over against midnight in all dvípas. In the same manner rising and setting are at all times opposite to each other in all the cardinal and intermediate points. When the sun becomes visible to any people, to them he is said to rise, and wherever he disappears from the view there his setting is said to take place. Of the sun which is always (above the earth) there is neither setting nor rising; his appearance and disappearance are called his setting and rising."*

The Súryaprajñapti adds an interesting account of other views regarding the sideway-motion (tiryag-gati) of the sun. According to some the sun is not a divinity, but only a mass of rays which in the morning form themselves in the East into a globular shape, pass sideways along this visible world, and in the evening dissolve again in the West. This process repeats itself daily. According to others the sun is the well-known divinity; but each morning he is born anew according to his nature in the ether in the East (svabhávád ákáśa utpadyate), passes along this world and dissolves (vidhvaṃsate) at evening in the ether in the West. According to others the sun is the mighty everlasting god known from the Puráṇas; in the morning he rises in the East, passes over this world, and at evening sets in the West; from thence he returns below to the East, illuminating the parts below. This—the commentator says—is the opinion of those who hold the earth to be a globe; it finds great favour at present among the tírthántaríyas and is thoroughly to be studied in their Puráṇas. This opinion has three sub-divisions. Some say the sun returning at daybreak from the parts below rises in the ether (ákáśe) and sets in the ether; others say he rises or originates (uttishṭhati utpadyate) in the morning on the summit of the mountain of rising (udaya-bhúdhara-śirasi) and perishes (? vidhvaṃsate) in the evening on the summit of the mountain of setting (astamaya-bhúdhara-śirasi); this repeats itself daily. (But, if he "utpadyate" and "vidhvaṃsate," how can he pass under the earth during the night?). Others say he rises in the morning on the mountain of rising and enters in the evening into the mountain of setting, illuminates during the night the subterraneous world and rises again from the mountain of rising. Others say, he rises, that is, originates from the eastern ocean in the morning, perishes at evening in the western ocean (same objection as above); others again, he rises from the eastern ocean, enters at evening into the western ocean, passes during the night through the subterraneous world, rises again from the eastern ocean. The last opinion mentioned is not very clear and an account of it is therefore not given in this place.

* Mr. Fitz-Edward Hall (Wilson's Vishṇu Puráṇa, Vol. II, p. 242) directs our attention to the "heliocentricism" taught in this passage. But clearly there is no trace of heliocentricism to be found in it. He apparently is misled by the words ह्यर्कस्य सर्वतः सतः which he translates "of the sun which is always in one and the same place." But this translation is quite untenable, since the Vishṇu Puráṇa most unambiguously teaches the sun's revolution round Mount Meru.

The third and fourth books contain particulars about the tápakshetra, *i. e.*, that part of the Jambudvípa which on each day is illuminated by the sun or rather by the two suns. The shape of this tápakshetra the Súryaprajñapti compares to that of a kalambuká-flower turned upwards, a comparison which has to be understood in the following manner. Each of the two suns illuminates a sector of the large circle formed by the Jambudvípa. These sectors are, however, not complete, but a piece is cut off from each by Mount Meru which standing in the middle of the circle repels by its own superior radiancy the rays proceeding from the two suns and therefore is not included in the tápakshetra. The interior border of the sectors is thus formed by a part of the circumference of Mount Meru, their outward border by a part of the circumference of the Jambudvípa. Between these two sectors of light there lie two sectors of shade (andhakára); whatever part of the Jambudvípa is covered by the two former enjoys day at the time while it is night in the regions covered by the dark sectors. As the two suns revolve these four sectors revolve with them, sweeping over the whole extent of the Jambudvípa and producing alternate day and night in all its parts. The relative magnitudes of the tápakshetra during the different parts of the year is estimated in accordance with the statements about the relative length of night and day. On the longest day the two suns, moving in the innermost circle, together illuminate three-fifths of the Jambudvípa, each of them three-tenths; on the shortest day they illuminate two-tenths each, together two-fifths. On the day after the summer solstice when the suns have entered into the second circle, and are moving at a greater distance from the centre, the extent of the tápakshetra decreases accordingly, so that it then equals $\frac{3}{5} - \frac{1}{5 \times 183} = \frac{3}{5} - \frac{1}{915}$ of the whole Jambudvípa only; the same decrease repeats itself daily up to the day of the winter solstice when the extent of the illuminated portion of the Jambudvípa has reached the minimum stated above. From that period it again begins to increase by the same portion daily. From this the absolute dimensions of the tápakshetra or, to express it more conveniently, of one of the two sectors composing the tápakshetra are easily derived. The two straight lines by which it is limited are equal in length to the radius of the Jambudvípa less the radius of Mount Meru (50,000 — 5,000 = 45,000 yojanas). To this we find in one passage of the Súryaprajñapti added the sixth part of the breadth of the salt ocean surrounding the Jam-

budvípa, up to the end of which the light of the sun seems to reach, on the longest day at least; this gives altogether $78{,}333\frac{1}{3}$ yojánas $\left(= 45{,}000 + \frac{200{,}000}{6}\right)$. In the statements regarding the measure of the two arcs limiting the sector, no reference is made to the salt ocean. We find these measures for the longest day by dividing the circumference of Mount Meru as well as that of the Jambudvípa by ten; three of these ten parts of the first kind give the interior arc of the truncated sector, three of the second kind the exterior arc. On the shortest day we have to take two-tenths instead of three, and there is no difficulty in finding the corresponding increase or decrease on all days between the summer and winter solstice. In the same manner the dimensions of the andhakára, the dark portion of the Jambudvípa, are readily ascertained. Finally some statements are made about the distances to which the light of the two suns reaches above, below and towards both sides. It is said to reach to a thousand yojanas above (above the chariot of the sun, svavimánád úrdhvam). Further it is said to reach down to the depth of 1,800 yojanas, for which the following explanation is given. The sun is at the height of 800 yojanas above the earth, and below the surface of the earth at the depth of 1 000 yojanas are the subterraneous regions (adholaukikagrámáḥ), down to which the sun's rays are penetrating. No further details about these subterraneous dwellings are given. Towards both sides, the east and the west, the light of the sun is said to extend to the distance of $47{,}263\,\frac{21}{60}$ yojanas.

For the sake of completeness, the various other opinions with regard to the subjects treated in the last paragraphs are added. Some say that the sun and moon illuminate one dvípa and one ocean; while according to others the numbers of dvípas and oceans illuminated are 3, $3\frac{1}{2}$, 7, 10, 12, 42, 72, 142, 172, 1042, 1072. No details are given. One chapter contains the enumeration of a number of very fanciful opinions about the form of the tápakshetra, which it would, however, be purposeless to extract in this place.

On the assumption that the sun describes every day a circle which is at the distance of $2\,\frac{48}{61}$ yojanas from the circle described on the preceding day, the question naturally suggested itself, how the sun passes over from one circle into the next one. This question is treated in I, 6, and II, 2 where two different opinions are expounded which, although the account given of them is not altogether clear, appear to be of the following nature. According to some the sun enters from one circle into the other, "bhedaghátena" which (bheda being explained to signify apántarála) seems to mean that the sun passes from one circle into the next one by moving over the distance separating the two all at once. Thus the sun would really move in perfect circles and the motion across from one circle into the other would be a momentary one only. The other opinion, and to this the Súryaprajñapti seems to adhere, is that the sun does not in reality move in separate perfect circles, but rather in an uninterrupted spiral line. As the Súryaprajñapti expresses it, the sun begins from the moment he has entered the first circle to move "śanaiḥ śanaiḥ" across towards the second circle, and as soon as he has reached the second circle, he begins to move towards the third circle, etc. The term "karṇa" which occurs in this description of the sun's motion seems to denote the spiral line which passing across the whole room between the two circles connects the two; a line which might properly enough be called "karṇa," *i. e.*, diagonal. On this hypothesis then we should have to remember that the sun is only for convenience sake said to describe a separate circle on each day, and that in reality he is supposed to describe a continuous spiral line.

After having thus given a succinct account of the Súryaprajñapti's theory concerning the motion of the sun, we now proceed to consider the statements referring to the motion of the moon.

(To be continued.)

Memorandum on Clay Discs called "Spindle Whorls" and votive Seals found at Sankisa, Behar, and other Buddhist ruins in the North Western Provinces of India.—By H. Rivett-Carnac, Esq., C. S., C. I. E., F. S. A. (With three Plates.)

Last year I submitted for the inspection of the Asiatic Society specimens of stone and clay discs, similar to what are called "spindle whorls" by the Antiquaries of Europe, found by me at the Buddhist ruins of Sankisa, Behar, &c. in the Fatehgaṛh District, N. W. Provinces of India. Certain clay seals stamped with the Buddhist formula found in the same localities were also exhibited. The resemblance between these "spindle whorls" and those described and figured by Dr. Schliemann in his work "Troy and its Remains" was briefly noticed by me at the time. Since then I have obtained some more specimens of these discs and seals, and I think it well that they should be submitted for the inspection of the Asiatic Society, and that the attention of its Members and of other Antiquaries should be directed to the resemblance to be traced between these remains and those found in the ruins of Hissarlik and in many parts of Europe.

First as regards so called "spindle whorls." When we were encamped at Kanouj, Sankisa and Behar Khas in the Fategarh district, the village urchins were encouraged to bring to us everything in the shape of "Antiquities" that could be grubbed out from these extensive ruins and from neighbouring mounds. These sites, as is well known, present many features

Temple.	Holdich.	Quarter-Master General.
Barminai	Baranmai Ba'memai	Bamemai.
Da'lo'r	Dalu'r	Dalur.
Sagharai	Sagre'	Sagre'.
China' Ko't	Chinna	Chinna.
Kachai	Katsai	Katsai.
Kana'	Khana	Khana.
Kach	Kats	Khas.
Sharan	...	Shoran.
Sha'ba'n	Shamurlak	Shamarlak.
Kaun Waha'r	Awaha'r	Awa'har.
Kuru	Khru	Khuru.
Hanumba'r	Anumba'r	Anambar.
Gadiwa'r	Gadba'r	Gadbar.
Sarghar Peak	Tatri	Tatari.
Lu'ni	Lu'ni	Lu'ni.
Shaugwa'l	Shahgolai	Shahgolai.
Tri'kh Kuram	Trekh Kuram	Trekh Kurram.
Raha	Raha	Rehi.
Tal	Tull	Tal.
Cho'tia'li	Cho'tia'li	Cho'tia'li.
Ko'lu	Ko'lu	Ko'lu.
Brahamzai Khela't	Pa'ramzai	Ba'ramzai.
Ma'r Pass	Ma'r	Ma'r.
Tsamaulang	Chama'lang	Chama'lang.
Hanokai Pass	Hannokai	Hannakoi.
Ba'la Dha'ka	Ba'lada'ka	Ba'llada'ka.
Mitthi' Khu'i'n	Hanku'a	Hanku'a.
Han Pass	Han	Han.
Ja'ndhra'n Hills	Ja'ndra'n	Ja'ndra'n.
Cho'r Tarap	...	Cho'r Ki' Tap.
Ba'han Kund	...	Ba'hanwa'la' Kach.
Chapar Hills	Chapar	Chapar.

On the Súryaprajñapti.—By Dr. G. Thibaut, *Principal, Benares College.*

Part II.

(*Continued from* p. 127.)

Although ancient Indian astronomy was chiefly interested in the moon and although the greater part of the Súryaprajñapti treats of her, especially of the places she occupies at different times in the circle of the nakshatras, a detailed connected account of her motions is not given anywhere, and we must combine the hints we meet with here and there, in order to understand the theory by which the old tírthankáras tried to explain to themselves her motion. In doing this we are of course greatly aided by the full and unambiguous account given of the sun's motion, since it will not be presuming too much that the theory which had been applied to the one luminary would be applied to the other one also. As we have seen above, the sun's daily apparent motion is regarded to be his true one and considered to take place round Mount Meru; his yearly motion is the consequence of his moving more slowly than the stars; his motion in declination is the result of his describing round Mount Meru circles of varying diameter. All this is applied to the moon too. The moon describes (or the two moons describe) circles round Mount Meru at the height of eight hundred and eighty yojanas above the earth, so that her place is eighty yojanas above that of the sun. She moves slower than the stars and slower than the sun; while the latter describes during one yuga 1,830 (or strictly speaking 915) circles, the moon describes only 1,768 (or again on the assumption of two moons 884) such circles; the difference of the two numbers = 62 indicates the number of times the moon enters into conjunction with the sun. During the same period, *viz.*, the quinquennial yuga, the moon completes sixty-seven sidereal revolutions. Each of these revolutions is, analogously to the sun's revolutions, divided into two ayanas, an uttaráyaṇa and a dakshiṇáyana, according as the moon is proceeding towards the north or the south (of the equator as we should add). In reality, it is true, the motion of the moon is much more complicated, as it is not only oblique to the equator, like the ecliptic in which the sun is moving, but also inclined to the ecliptic itself at an angle of about 5°, while moreover at the same time the points in which the moon's path cuts the ecliptic are continually receding. One of the consequences of the revolution of the nodes did, as we shall see below, not escape the observation of the author of the Súryaprajñapti, but he was manifestly unable to account for it by a modification of his theory. According to him the moon, like the sun, simply describes concentric circles round Mount Meru, some-

times approaching it sometimes receding from it. While, however, the period of the sun's progress from and towards Mount Meru comprises one year—the time which the sun employs in arriving again at the same star—the corresponding period of the moon embraces one nakshatra month = 27 days, 9 $\frac{27}{67}$ muhúrtas. From this it is easy to find the number of the circles the moon describes. She performs during one yuga 1,768 complete revolutions, consequently during one nakshatra month $\frac{1768}{67} = 26\frac{26}{67}$ revolutions, and during one ayana or sidereal half month $13\frac{13}{67}$ revolutions. The moon therefore proceeds towards the north during the time which she wants for describing $13\frac{13}{67}$ circles, and after that she proceeds towards the south for the same length of time. From this it follows that, while the sun has 184 different circles to describe, the moon has fifteen such circles only. At the beginning of the yuga she leaves the outermost circle and begins her uttaráyaṇa, describes the thirteen circles intermediate between the outermost and the innermost ones and enters into the fifteenth (innermost) circle, through $\frac{13}{67}$ parts of which she passes. After that the sidereal half moon has elapsed, and the moon has to retrace her steps towards the south. She therefore leaves the innermost circle unfinished, returns into the next one, passes again through the 13 intermediate circles and enters into the 15th (outermost) circle. After she has passed through $\frac{13}{67}$ parts of the latter, the sidereal half moon is again over and the progress towards the north recommences. Thus the moon moves in 15 circles of different diameter, but only 13 she passes through in their entirety while a fractional part only of the two exterior circles are touched by her. We have seen above that the vikampa-kshetra of the sun, *i. e.*, the extent to which the sun moves sideways in his northern and southern progress is estimated at 510 yojanas ($= 183 \times 2\frac{48}{61}$; the latter quantity being the amount of the daily vikampa) ; the vikampa-kshetra of the moon is estimated at nearly the same amount, *viz.*, $509\frac{53}{61}$ yojanas (it has been already remarked that the inclination of the moon's path to the ecliptic is not known to the Súryaprajñapti). The diameter of the moon herself is estimated at $\frac{56}{61}$ yojanas, the interval between consecutive circles described by the moon at $35 + \frac{30}{61} + \frac{4}{7 \times 61}$ yojanas ; the sum of these two quantities is $36 + \frac{25}{61}$

$+ \frac{4}{7 \times 61}$, which multiplied by 14, gives the above stated amount $\left(509\frac{53}{61}\right)$ as the whole vikampakshetra during one lunar half month. Here—as likewise above with reference to the sun—the Súryaprajñapti does not directly speak of the diameter of the moon, but of the measure of the breadth of the circle described by the moon ; but the two things come to the same. The manner in which the moon, after having completed one of her circles, passes over into the next one is not expressly detailed ; we must imagine it similar to that of the sun.

In connexion with this account of the moon's motion, the Súryaprajñapti enters into a curious calculation, of no practical, and it can hardly be said any theoretical interest, which, however, may be mentioned here as a specimen of the accuracy with which the system is worked out into its minutest details. The question is raised : what circles are common to the sun and moon and how far are those of the moon's circles which belong to the sun also touched by the latter ? As the moon's circles are elevated above those of the sun by the amount of eighty yojanas, strictly speaking not any circle is common to both ; common to both are, however, said to be those circles of the moon which when projected upon the plane in which the sun describes his circles partially or entirely coincide with the latter. The vikampa-kshetras of the two being nearly equal, while 15 circles of the moon correspond to 184 circles described by the sun, the consequence is that the by far greater portion of the sun's circles do not coincide with the moon's circles, but fall into the wide intervals separating the latter, one from another. Thus for instance the first (innermost) circle of the sun coincides with the first circle of the moon, so that when both luminaries move in their innermost circles their distance from Mount Meru is equal ; only the circle of the moon overlaps that of the sun by $\frac{8}{61}$ yojanas, this being the difference of the breadth of the circles described by the two (of the diameters of the two bodies). The next twelve circles of the sun all fall into the interval between the first and the second circle of the moon ; for this interval (plus the overlapping $\frac{8}{61}$ of the first circle) amounts to $35 + \frac{38}{61} + \frac{4}{7 \times 61}$ yojanas, while the vikampa-kshetra of twelve solar circles amounts to $33\frac{27}{61}$ yojanas only. After that two yojanas are occupied by the interval between the 13th and the 14th solar circles, and then the fourteenth solar circle begins, which therefore partly coincides with the second lunar circle. By continuing these calculations for all lunar circles, it is

found that the first up to the fifth inclusive, and again the eleventh up to the fifteenth inclusive are "súrya-sammiśráṇi," *i. e.*, partly coincide with solar circles, while the sixth up to the tenth do not coincide with solar circles, the latter falling entirely into the intervals between the named lunar circles. To reproduce here all the details of the calculation would be purposeless.—That the preceding account of the moon's motion agrees with the ideas of the author of the Súryaprajñapti is to be concluded from the formulas given in different parts of the work for the performance of certain calculations. Thus for instance the question is raised, in what ayana and what circle each parvan takes place, *i. e.*, how many ayanas have elapsed at the different times when the moon enters into conjunction or opposition and in which of the fifteen circles she is moving just then. This question is answered by some ancient gáthás quoted in the commentary, according to which the calculation has to be made as follows. The constant quantity—the ध्रुवराशि—which is to be used for the calculation of each parvan, is equal to $1 + \frac{4}{67} + \frac{9}{31 \times 67}$, *viz.*, of one of the circles described by the moon. This quantity is of course easily found by the following consideration. The moon which describes in one yuga 1,768 circles describes in one parvan $\frac{1768}{124} = 14\frac{8}{31}$ circles and in one ayana $13\frac{13}{67}$ circles; the difference of these two quantities is the above mentioned constant quantity. The rule for finding the places of the parvans is now as follows: The way accomplished by the moon during one parvan being equal to the way accomplished during one ayana plus $1 + \frac{4}{67} + \frac{9}{31 \times 67}$ circles, take at first as many ayanas as the number of the parvan whose place is wanted indicates, multiply then the constant quantity by the number of the parvan, and if the result exceeds $13\frac{13}{67}$, deduct it from this latter quantity (which subtraction if necessary has to be repeated until the remainder is less than $13\frac{13}{67}$); as often as this subtraction is performed as many unities are to be added to the number of ayanas found above and—unless the subtraction leaves no remainder—one additional unity is to be added; add two to the remainder; the resulting sum will indicate the circle in which the moon stands at the parvan. Regarding this latter point it is to be remembered that the circles are to be counted from the innermost circle when the number of the parvan is an even one and from the outermost circle when it is an odd one. To illustrate this let us take one of the many examples given by the Commentator. Required the place of the moon at the fourteenth parvan. Multiply at first one by fourteen, that means: fourteen ayanas have elapsed

at the time. Then multiply $1 + \frac{4}{67} + \frac{9}{31 \times 67}$ by fourteen; the result is $14 + \frac{56}{67} + \frac{126}{31 \times 67} = 14 + \frac{60}{67} + \frac{2}{31 \times 67}$. This is the number of circles which the moon has passed through during fourteen parvans in addition to fourteen ayanas. As this number exceeds the number of circles passed through in one ayana (*viz.*, $13\frac{13}{67}$), the latter number has to be deducted from it and one has to be added to the number of ayanas. So we see that the moon has performed 15 ayanas at the end of the 14th parvan. The remainder left after the above deduction shows the number of circles which the moon has passed through in addition to the 15 complete ayanas; in our case these amount to $1 + \frac{47}{67} + \frac{2}{31 \times 67}$. As there is an excess above 15 complete ayanas, we have according to the rule to add one to their number, *i. e.*, the parvan takes place in the sixteenth ayana. And since the moon enters at the beginning of the ayana into the second circle (the circles being counted from the innermost as well as the outermost) and since in our case the moon has completed more than one full circle, two has to be added to the number of circles found above in order to obtain the ordinal number of the circle in which the moon stands at the expiration of the 14th parvan. The full answer is therefore: the 14th parvan takes place in the sixteenth ayana, in the third circle (reckoning from the innermost circle), $\frac{47}{67} + \frac{2}{31 \times 67}$ of this circle having already been passed through. In the same manner the places of all other parvans may be easily found; the commentator gives the places of parvan I—XV; but it would serve no purpose to extract them here. What has been given will suffice to justify the hypothetical account of the moon's motion detailed above.

The question regarding the relative velocity of sun, moon and stars which is raised in the 15th book finds its answer in accordance with the general principles of the system. The apparent daily motion being considered as the real one, it follows that the nakshatras travel faster than the sun, and the sun again faster than the moon; the space passed through by each of these bodies during a month, day, muhúrta, etc. is calculated and exhibited in detail; we need, however, only remember that the sun describes in one yuga 1,830 circles, while the moon describes only 1,768 and the nakshatras—through whose circle the sun passes five times—describe 1,835. From these relations all special values can be easily derived. It is just mentioned—no details being given—that the planets (graha) travel faster than the sun and the stars (táráḥ) faster than the nakshatras. It is needless to discuss the former of these two assertions; the latter is of course

entirely indefensible and no reason leading to it can well be imagined. This is the only time that the stars—excluding the nakshatras—are mentioned in the Súryaprajñapti as far as we can judge from the commentary.

The next point to be considered is the information the Súryaprajñapti furnishes with regard to the nakshatras. Incidentally it has already been remarked that the number of the nakshatras is invariably stated as being twenty-eight, and that the nakshatras are as invariably treated as being of different extent. The particulars are as follows:

According to their extent or, to look at it from another point of view, according to the time during which sun and moon are in conjunction with them, the nakshatras are divided into four classes. Firstly, those with which the moon is in conjunction during one ahorátra = thirty muhúrtas; to this class belong Revatí, Aśviní, Kṛittiká, Mṛigaśiras, Pushya, Maghá, Púrvaphálguní, Hasta, Chitrá, Anurádhá, Múla, Púrváshádhá, S'ravaṇa, S'ravishṭhá, Púrvabhádrapadá. The one ahorátra for which the conjunction lasts may be expressed as $\frac{2010}{67}$ muhúrtas, the convenience of which expression will appear at once. The second division comprises those nakshatras which are in conjunction with the moon for half a nycthemeron = fifteen muhúrtas = $\frac{1005}{67}$ muhúrtas; to this division belong S'atabhishaj, A'śleshá, Bharaṇí, Jyeshṭhá, A'rdrá, Svátí. To the third division belong those nakshatras with which the moon is in conjunction for one and a half nycthemeron = 45 muhúrtas = $\frac{3015}{67}$ muhúrtas; these nakshatras are Uttaráshádhá, Uttaraphálguní, Uttara-bhádrapada, Punarvasu, Viśákhá, Rohiṇí. The fourth division comprises one nakshatra only, *viz.*, Abhijit, with which the moon is in conjunction for $9\frac{27}{67} = \frac{630}{67}$ muhúrtas. We see now for what reason the time of conjunction has been expressed throughout in sixty-sevenths of a muhúrta; it was done for the purpose of obtaining homogeneous expressions for all nakshatras. At the same time these fractions furnish us with an easy means for calculating the time during which the sun is in conjunction with each nakshatra; for five revolutions of the sun occupying the same time as sixty-seven revolutions of the moon, we have only to replace the denominator of the above fractions by five. The result of this operation having been turned into nycthemera, we find as the expression for the time during which the sun is in conjunction with the nakshatras of the four divisions the four following terms: 13 days, 12 muhúrtas; 6 days, 21 muhúrtas; 20 days, 3 muhúrtas; 4 days, 6 muhúrtas.—According to the space the nakshatras occupy they are either samakshetra, occupying a mean (medium) field or apárdhakshetra, occupying half a field or dvyardhakshetra, occupying one field and a half. There is no special name for the extent of Abhijit.

In connexion with this division of the nakshatras into different classes according to the space they occupy or the time during which they are in conjunction with the moon, there is another one referring to the time of the day or the night at which they enter into conjunction. This classification is, however, connected with considerable difficulties. It is nowhere clearly stated on the conjunctions of what particular month this division is based; that such a statement ought to have been given, appears from the consideration that the periodical month during which the moon passes through all nakshatras comprises 27 days plus $\frac{27}{67}$ days, and that therefore in the second, third, fourth, etc. months the times at which the moon enters into conjunction with the single nakshatras will all differ from the times of the first month. If for instance the moon at the beginning of the first month enters into conjunction with Abhijit in the early morning, she will at the beginning of the second month again enter into conjunction with it $9\frac{27}{67}$ muhúrtas later, that is, in the afternoon and so on. Other difficulties will appear from the following detailed reproductiou of the Súryaprajñapti's account concerning this point. The nakshatras are either "púrvabhága" *i. e.*, such as enter into conjunction with the moon during the forenoon; or "páschádbhága" *i. e.*, such as enter into conjunction during the afternoon or "naktambhága" *i. e.*, such as enter into conjunction during the night or "ubhayabhága" which term will be explained further on. The nakshatras of the two first classes are the samakshetras, those of the third class the apárdhakshetras, those of the fourth class the dvyardhakshetras. It certainly does not appear why the samakshetras should enter into conjunction with the moon during the day only and the apárdhakshetras during the night only; in reality there is no connexion between the extent of a nakshatra and the time when the moon enters into it. Let us, however, follow the detailed statements about each single nakshatra. The first aphorism of the Súryaprajñapti appears to be "Abhijit and S'ravaṇa are paśchádbhága samakshetra." To this the commentator rightly objects that Abhijit is neither samakshetra, since it occupies only $9\frac{27}{67}$ muhúrtas of the moon's periodical revolution, nor paśchádbhága, since at the beginning of the yuga the moon enters into conjunction with it in the early morning. At the same time he tries to obviate these objections by remarking that Abhijit is called samakshetra and paśchádbhága, because it is always connected with S'ravaṇa to which both these attributes rightly belong, or that it may be called paśchádbhága with a view to conjunctions other than the

first one which may take place in the course of the yuga. But these both attempts at reconciling contradictions are very unsatisfactory. Howsoever this may be, the commentator goes on to explain that Abhijit and S'ravaṇa, after having finished their conjunction with the moon, hand her over to Dhanishṭhá at evening (Abhijit-śravaṇo dve nakshatre sáyam-samayád árabhya ekám rátrim ekam cha sátirekam divasam chandreṇa sárddham yogam yuktaḥ etávantam kálam yogam yuktvá tad-anantaram yogam anuparivartayataḥ átmanaś chyávayataḥ yogam chánuparivartya sáyam divasasya katitame paśchádbhága chandram dhanishṭháyáḥ samarpayataḥ). For this reason Dhanishṭhá also is paśchádbhága. After having been in conjunction with it for thirty muhúrtas the moon enters S'atabhishaj at the time when the stars have already become visible (parishphuṭanakshatramaṇḍalávaloke); S'atabhishaj is therefore naktambhága. How S'atabhishaj enters into conjunction at night, while exactly one ahorátra before Dhanishṭhá has been said to enter into conjunction during the afternoon, is not explained. S'atabhishaj being apárdhakshetra, the moon remains in conjunction with it for fifteen muhúrtas only and enters on the next morning into conjunction with Púrva-proshṭhapada, which being samakshetra remains in conjunction during one whole ahorátra. On the following morning the moon enters Uttara-proshṭhapada, which therefore would be púrvabhága. But the matter is looked at in a different light, Uttara-proshṭhapada is dvyardhakshetra, *i. e.*, remains in conjunction for 45 muhúrtas. If we now deduct from this duration the fifteen first muhúrtas and imagine Uttara-proshṭhapada to be samakshetra, the conjunction of the moon with it—looked at as samakshetra—may be said to take place at night and in consequence one—the real—conjunction taking place during the day and the other—the fictitious one—taking place at night the nakshatra is called ubhayabhága (idam kilottarabhádrapadákhyam nakshatram uktaprakáreṇa prátaś chandreṇa saha yugam adhigachchhati, kevalam prathamán pañchadaśa muhúrtán adhikán apaníya samakshetram kalpayitvá yadá yogaś chintyate tadá naktam api yogo 'stíty ubhayabhágam avaseyam). Uttarabhádrapada remains in conjunction for one day, one night and again one day, on the evening of which the moon enters Revatí; Revatí is therefore paśchádbhága. After it has remained in conjunction for one nychthemeron the moon passes into Aśviní at evening time. Aśviní is therefore likewise paśchádbhága. From it the moon passes on the next evening into Bharaṇí, at the time, however, when the stars have become visible and night may be said to have begun; Bharaṇí is therefore naktambhága. Being at the same time apárdhakshetra, the moon leaves it on the next morning to enter Kṛittiká, which therefore is púrvabhága. On the next morning the moon enters Rohiṇí which is dvyardhakshetra and, on account of that, ubhayabhága. Mṛigaśiras which she enters forty-five muhúrtas

later at evening is paśchádbhága; A'rdrá which enters into conjunction thirty muhúrtas later, at the time when the stars have come out, is naktambhága; Punarvasu into which the moon enters on the next morning, being dvyardha, is ubhayabhága. Pushya comes into conjunction on the evening of the following day and is paśchádbhága; A'ślesha thirty muhúrtas later, when the stars have come out, and is naktambhága; Maghá and Púrvaphalguní into which the moon enters on the mornings of the two following days are púrvabhága; Uttara-phalguní which comes into conjunction on the morning after that is ubhayabhága, because it is dvyardhakshetra. Hasta and Chitrá enter into conjunction on the evenings of the two following days, before night has set in, and are therefore paśchádbhága. Then again follows one naktambhága nakshatra, *viz.*, Svátí which enters into conjunction after nightfall, and upon this a dvyardhakshetra and consequently ubhayabhága nakshatra, *viz.*, Viśákhá. Then Anurádhá paśchádbhága, after this Jyeshṭhá, apárdhakshetra and naktambhága, remaining in conjunction from nightfall to the morning only; after this two samakshetra and púrvabhága nakshatras, *viz.*, Múla and Púrváshádhá. And finally Uttaráshádhá, which enters into conjunction on the morning, is, however, as a dvyardhakshetra, reckoned among the ubhayabhága. It remains in conjunction for one nycthemeron and the following day, in whose evening the moon arrives at Abhijit whence she had started a (periodical) month ago.

The difficulties involved in all the preceding statements are increased by an assertion made in another chapter of the Súryaprajñapti, *viz.*, that no nakshatra always enters into conjunction with the moon at the same time of the day. This is indeed true, but it contradicts the preceding statements. It may be that this whole classification of the nakshatras according to the time of the day at which they enter into conjunction with the moon is a remainder of an earlier stage of knowledge, when the periodical month was supposed to last just twenty-seven days without an additional fraction, and when it therefore was possible to assign to each nakshatra one fixed hour at which it entered into conjunction during each periodical revolution of the moon. It is true that actual observation would speedily have shown the error of such an assumption, but this remark would apply to almost all hypotheses of the Indians of that period, and we may therefore suppose that in this point too the desire of systematizing prevailed during a certain period over the testimony of the eyes. Later on when the duration of the periodical month had become better known, the old classification lost its foundation entirely and ought to have been dropped; but through the force of custom it maintained its place and was justified some how, although not with the best success, as we have had occasion to observe above.

On the places of the nakshatras with regard to the moon we receive

the following information (X. 11). Six nakshatras, *viz.*, Mṛigaśiras, Árdrá, Pushya, Áśleshá, Hasta, Múla always stand to the south of the moon whenever she enters into conjunction with them. Twelve nakshatras—Abhijit, S'ravaṇa, Dhanishṭhá, S'atabhishaj, Púrva-bhádrapadá, Uttara-bhádrapadá, Revatí, Aśviní, Bharaṇí, Púrva-phálguní, Uttara-phálguní, Sváti always stand to the north of the moon. Seven nakshatras—Kṛittiká, Rohiṇí, Punarvasu, Maghá, Chitrá, Viśákhá, Anurádhá—sometimes stand to the north of the moon entering into conjunction with them; sometimes, however, the moon enters into conjunction with them "pramardarúpeṇa" *viz.*, in such a manner that she passes right through them. To this class, the commentator remarks, some teachers holding an opinion different from that of the Súryaprajñapti add also Jyeshṭhá. Two nakshatras, *viz.*, the two Áshádhas stand at the time of conjunction either to the south of the moon or the latter passes right over them. Both these nakshatras consist of four stars each, two of which are situated inside, *viz.*, to the north of the fifteenth circle of the moon, while the two remaining ones are placed outside, *viz.*, to the south of the same circle. Now whenever the moon enters into conjunction with either of the two nakshatras, she passes right between the former pair of stars and may therefore be said to be in conjunction "pramardarúpeṇa." Finally one nakshatra, *viz.*, Jyeshṭhá, always enters into conjunction with the moon pramardarúpeṇa. Regarding the relation of the nakshatras to the fifteen circles of the moon, the following statements are made. Eight circles always are "undeprived" (avirahitáni) of nakshatras. The twelve nakshatras mentioned above, beginning with Abhijit, are in the first circle; in the third circle there are Punarvasu and Maghá; in the sixth, Kṛittiká; in the seventh, Rohiṇí and Chitrá; in the eighth, Viśákhá; in the tenth, Anurádhá; in the eleventh, Jyeshṭhá; in the fifteenth, Mṛigaśiras, Árdrá, Pushya, Áśleshá, Hasta, Múla and the two Asháḍhás. For although the first six of the last mentioned class in reality move outside the fifteenth circle, they are—the commentator says—so near to it that they may be said to be in it. In order to form a right estimate of the meaning and the value of these statements, we must recall to our mind what has been remarked above about the Súryaprajñapti's theory of the moon's motion. The moon is supposed to proceed alternately towards the south and the north in the same way as the sun does, following—as the Súryaprajñapti seems to assume—the same path; that she in addition to the movement in declination has a movement in latitude, and that the points in which her orbit cuts the ecliptic are continually receding is ignored, theoretically at least, although it had been observed that the position of the moon with regard to some nakshatras is different at different times, that she sometimes passes on the north or south-side of a constellation and at other times moves right through it. Now comparing the particulars

with the information given about the position of the nakshatras in the Siddhántas, we find that the Súryaprajñapti agrees with the latter with regard to five out of the six nakshatras said always to stand south of the moon (Mṛigaśiras, Árdrá, Áśleshá, Hasta, Múla), the latitude of all of them considerably exceeding the highest latitude the moon ever reaches. The case lies differently with regard to Pushya, which according to the Siddhántas lies in the ecliptic, so that it almost appears as if the Pushya of the Súryaprajñapti were an altogether different asterism. From among the twelve nakshatras said to stand always north of the moon ten (Abhijit, S'ravaṇa, S'ravishṭhá, Púrva-Bhádrapadá, Uttara-Bhádrapadá, Aśviní, Bharaṇí, Púrva-Phálguní, Uttara-Phálguní, Sváti) may be identified with the nakshatras of the Siddhántas whose latitudes—excluding Abhijit—vary from 9° to about 39° north. Strange it is only that these nakshatras occupying a zone of about 21° breadth are said to be in one and the same circle of the moon, and still stranger that Abhijit too is classed among them, the latitude of the latter—if identical with the Abhijit of the Siddhántas—exceeding the latitudes of the other nakshatras, with which it is here thrown into one class, by about 30°. The S'atabhishaj and Revatí of the Siddhántas are situated in and close to the ecliptic; here too therefore we might doubt if the Súryaprajñapti denotes by these two names the same stars as the Siddhántas. The remaining nakshatras may be identified with those of the Siddhántas, the latitude of none of the latter much exceeding the greatest latitude reached by the moon; a considerable margin must of course be allowed for the inaccuracy of the observations on which the statements of the Súryaprajñapti are based. Quite unfounded is the statement about the moon always passing right through Jyeshṭhá; it looks as if it had originated at some period when one of the moon's nodes had about the same longitude as that asterism.

The order of succession of the nakshatras is treated in X. 1. Of five different pratipattis regarding this point the author details only one, *viz.*, that one according to which Kṛittiká stands first. The author of the Súryaprájñapti for his part calls Abhijit the first nakshatra, since according to his system at the beginning of the yuga on the day of the summer solstice early in the morning the moon which is full at that time stands in Abhijit. He therefore altogether abandons the principle, sometimes followed, according to which the enumeration of the nakshatras begins with that nakshatra in which the sun stands on the day of the vernal equinox; if he too had chosen this principle he would of course have begun his enumeration with Aśviní. It may here be mentioned by the way that the Súryaprajñapti does not occupy itself at all with the equinoxes, the name of which is not even mentioned in the whole work.

We now proceed to consider some specimens of the numerous cal-

culations, rules for the performance of which are contained in the Súryaprajñapti itself as well as in a great number of old karaṇa-gáthás quoted by the commentator; remarking at once that the rules contained in the gáthás presuppose exactly the same system as the rules of the Súryaprajñapti itself. A comparison of these calculations with those contained in the jyotisha-vedáñga shows the extreme likeness and in many cases the complete identity of the two sets; a result which supplies another reason for looking on the Súryaprájñapti as—in all essential points—a fair representative of Indian astronomy anterior to the period of the Siddhántas. Several of these calculations have already been reproduced above incidentally; in the following a detailed account of the more important ones among those not yet touched upon will be given.

It appears that before the influence of Greek astronomy made itself felt in India, the division of the sphere into 27 or 28 nakshatras was the only one employed and that no independent subdivisions of the nakshatras were made use of. This want was, however, supplied by a simple transfer of the subdivisions of time to the nakshatras. In accordance with this principle the Súryaprajñapti divides the sphere into $819 \frac{27}{67}$ muhúrtas, this being the duration of the periodical revolution of the moon, and allots to each nakshatra a certain number of muhúrtas according to its greater or smaller extent. Fixed subdivisions of the muhúrta such as are commonly met in Indian astronomical works are, however, nowhere employed by the author of the Súryaprajñapti; he apparently preferred to keep himself perfectly free from restrictions of this kind and uses throughout those fractions of the muhúrta only which were immediately suggested by the various calculations in hand. From the general nature of the yuga it is manifest at once which fractions will present themselves most readily; they are sixty-seconds and sixty-sevenths (62 = number of synodical months in a yuga, 67 = number of periodical months) and, whenever lunar months of both kinds enter into the calculations, sixty-sevenths of sixty-seconds.

One of the most important rules is that which teaches how to find the place of the moon on any parvan. In the following the details of the calculation furnished by the commentator will be stated in extenso, so that at least one complete specimen of computations of this kind may be exhibited.—If we wish to devise a rule for calculating the place of the moon in the circle of the nakshatras at any parvan, we must at first find the constant quantity—the dhruvaráśi—entering as a multiplicand into all calculations of this kind. This in our case is clearly the space passed through by the moon during the lunar month, or more simply, because entire revolutions which bring the moon back to the same place can be neglected, the excess of the lunar synodical month above the periodical

month. From what is known about the general constitution of the yuga this quantity is of course readily found to be equal to $66 + \frac{5}{62} + \frac{1}{62 \times 67}$. The commentator calculates this quantity as follows. If the sun performs during 124 parvans five complete revolutions, how much does he perform during 2 parvans (= one synodical month); answer: $\frac{5 \times 2}{124} = \frac{5}{62}$ rev. This therefore is the excess of the synodical month above the periodical one. In order that the division can be carried out, the $\frac{5}{62}$ rev. are turned into nakshatras by multiplying them by $\frac{1830}{67}$ (*i. e.* by $27 \frac{21}{67}$, the duration in ahorátras of the periodical month or, if we like, the extent of the nakshatras; 27 entire nakshatras plus the fractional nakshatra Abhijit). Result of the multiplication $\frac{9150}{4154}$. Again—in order to turn the days or nakshatras into muhúrtas—the numerator is multiplied by 30. Result $= \frac{274500}{4154}$. This division being performed gives as result 66 muhúrtas. The remainder 336 is multiplied by 62 and the product again divided by 4154. Result $= \frac{5}{62}$ muhúrtas. The remainder—62—should again be multiplied by 67 (the fractions employed being throughout sixty-seconds and sixty-sevenths) and divided by 4154; but 4154 being itself = 62 × 67, it is seen at once that the result is 1. Thus the whole quantity is $66 + \frac{5}{62} + \frac{1}{62 \times 67}$ muhúrtas. If now the place of the moon at any amávasyá or púrṇamásí is wanted, the above quantity has to be multiplied by the number of the parvan; for instance, by one if the moon's place at the first full moon after the beginning of the yuga is wanted. The product shows how far the moon at the time has advanced beyond the place she had occupied at the beginning of the yuga, if full moons are concerned, or beyond the place she had occupied at the new moon preceding the beginning of the yuga, if new moons are concerned, (the new moon immediately antecedent to the beginning of the yuga having been selected as starting-point for all calculations concerning new moons). So far the place of the moon is expressed in muhúrtas only; now in order to find from these the nakshatra in which the moon stands at the time, we should

have to deduct from the muhúrtas found the extent of all the nakshatras through which the moon has passed one after the other, until the sum would be exhausted. Thus, for instance, if we wanted to find the place of the moon at the third new moon after the beginning of the yuga, the constant quantity $66 + \frac{5}{62} + \frac{1}{62 \times 67}$ would have to be multiplied by 3, so that we should have $198 + \frac{15}{62} + \frac{3}{62 \times 67}$ muhúrtas. Now the moon standing at the new moon preceding the beginning of the yuga in Punarvasu, of which she has still to pass through $22\,\frac{46}{62}$ muhúrtas, we should have to deduct this last quantity from $122 + \frac{10}{62} + \frac{2}{62 \times 67}$; from the remainder we should have to deduct 30 muhúrtas (the extent of Pushya); from the remainder again 15 (Áśleshá); again from the remainder 30 (Maghá), and so on, until in the end the fact of the remainder being smaller than the next following nakshatra would show that new moon takes place in that nakshatra.—In order, however, to shorten this somewhat lengthy process, certain subtrahends are formed out of the sum of the extent of several nakshatas, which materially alleviate the work by substituting one subtraction for a number of subtractions. Thus with reference to new moon—the subtrahend (śodhanaka) for Uttara-phálguní is said to be 172, for Viśákhá 292, for Uttara-áshádhá 442; *i. e.*, if from the product of the constant quantity by the number of the new moon 172 can be deducted, we see at once that the moon has advanced beyond Uttara-asháḍháḥ; if 292 can be deducted, she has passed the limits of Viśákhá and so on. The subtrahends are not carried on from Punar-vasu beyond Uttara-ásháḍhá, but make a fresh start from Abhijit, apparently in order to make them available for the calculation of the places of the full moons too. Thus the subtrahend for Abhijit is 9 and a fraction, of Uttara-bhádrapadá 159, of Rohiṇí 309, of Punarvasu 399, of Uttara-phálguní 549, of Viśákhá 669, of Múla 744, of Uttara-asháḍhá 819.

The places in which the different full moons of the yuga occur are found by an exactly similar proceeding; only all calculations have to start not from Punarvasu, but from the beginning of Abhijit where the first full moon which coincides with the beginning of the yuga takes place. The text enumerates the places of all full moons and new moons of the yuga at length, carrying in each case the calculations down to sixty-sevenths of sixty-seconds of muhúrtas. It is needless to reproduce these lists here in extenso, as any place wanted can be calculated with ease from the general rule given above.

The same result, *viz.*, to find the place of the moon on a given parvan is obtained by following another rule contained in some gáthás quoted by the commentator. Their purport is as follows. Multiply sixty-seven (the number of periodical revolutions which the moon makes during one yuga) by the number of the parvan the place of which you wish to find and divide this product by one hundred and twenty-four (the number of parvans of one yuga). The quotient shows the number of whole revolutions the moon has accomplished at the time of the parvan. The remainder is to be multiplied by 1830 (*viz.*, 1830 sixty-sevenths which is the number of nycthemera of one periodical month) or more simply by 915 (reducing 1830 as well as the denominator *viz.*, 124 by two). From the product (remainder multiplied by 915) deduct 1302, which is that part of a whole revolution which is occupied by Abhijit (Abhijit occupies $\frac{21}{67}$ days, but as this amount is to be deducted from the numerator of a fraction the denominator of which is 62, 21 is to be multiplied by 62; product = 1302). The portion of Abhijit, from which the moon's revolutions begin, is deducted at the outset, because it is greatly smaller than the portion of all other nakshatras and would disturb all average calculations. After it is has been deducted the remainder is divided by 67×62; the quotient shows the number of nakshatras beginning from S'ravaṇa which the moon has passed through, in addition to the complete revolutions. The remainder is again multiplied by thirty, the product divided by 62; the quotient shows the number of muhúrtas during which the moon has been in the nakshatra in which she is at the time. And so on down to small fractions of nakshatras. The following is an example. Wanted the place of the moon at the end of the second parvan. Multiply 67 by 2; divide the product by 124. The quotient (1) indicates that the moon has performed one complete periodical revolution. The remainder (10) is multiplied by 1830 or more simply by 915 (see above); from the product (9150) the portion of Abhijit (1302) is deducted. The remainder (7848) is divided by $67 \times 62 = 4154$; the quotient (1) shows that after Abhijit the moon has passed through one complete nakshatra, *viz.*, S'ravaṇa. The remainder (3694) is multiplied by 30; the product (110820) again divided by 4154; the quotient (26) shows that the moon has moreover passed through 26 muhúrtas of S'ravishṭhá. By carrying on this calculation we arrive at the result that at the end of the second parvan the moon stands in S'ravishṭhá, of which she has passed through $26 + \frac{42}{62} + \frac{2}{62 \times 67}$ muhúrtas.

Analogous calculations are made for the sun too. For instance, in what circle does the sun move at the time of each parvan? The rule here is very simple. Multiply the number of the parvan by fifteen (the number

of tithis of one parvan) and from the product deduct the number of avamarátras (excessive lunar days) which occur during the period in question. If the parvan occurs during the first ayana of the sun, the remainder immediately indicates the number of the solar circle which is in fact the same as the number of the civil day on which the parvan happens; if the parvan takes place during one of the other nine ayanas, the remainder must at first be divided by 183 (number of circles described by the sun during one ayana); etc. The rule is simple and needs no illustration.

The rule for finding the nakshatra in which the sun stands at the time of each parvan (the súryanakshatra) is quite analogous to the rule given above for the moon. The sun makes in one yuga five complete revolutions, in one parvan $\frac{5}{124}$ revolutions. This quantity is to be multiplied by the number of the parvan and then we have as above to descend by continued multiplication and division to nakshatras, sixty-second parts of nakshatras and sixty-seventh parts of sixty-second parts. Instead of deducting the portion belonging to Abhijit at the beginning of which the moon stands on the first day of the yuga, we have to deduct that part of Pushya which the sun has not yet passed through at the beginning of the yuga; it amounts to $\frac{44}{67}$ of a nychthemeron. All the remainder of the calculation is the same as in the moon's case and illustrative examples are therefore not wanted.

Besides there is another and considerably simpler method for finding the sun's place at the end of a parvan; it is likewise contained in some old karaṇa-gáthás. The rule again assumes a "dhruvaráśi", a constant quantity, to be used in all calculations of this kind. This quantity is $33 + \frac{2}{62} + \frac{34}{62 \times 67}$ muhúrtas; for if we divide the whole circle of the nakshatras into $819\frac{27}{67}$ muhúrtas (which is the time occupied by a complete revolution of the moon) the above amount expresses the way the sun accomplishes during one parvan. This quantity has therefore to be multiplied by the number of the parvan required, and by subtracting from the product at first the $19 + \frac{43}{62} + \frac{33}{67 \times 62}$ muhúrtas belonging to Pushya, after that the 15 muhúrtas of Áśleshá, after that the 30 muhúrtas of Maghá etc., we find in the end the nakshatra in which the sun completes the parvan. In order to facilitate these somewhat lengthy subtractions, the muhúrtas of a certain number of nakshatras are again added and presented in a tabular form. So for instance 139 muhúrtas (19 + 15 + 30 + 30 + 45) lead us up to

the end of Uttara-phálguní, and if therefore the product found in the manner shown above exceeds 139, we may at once subtract 139 instead of performing five separate subtractions and know that the sun has at the time passed beyond Uttara-phálguní. The procedure is analogous to the one described above and needs no further illustration.

For finding how many seasons have elapsed on a certain tithi, the commentator quotes some gáthás of the old teachers. The rule they contain is as follows. Multiply the number of the parvans which have elapsed since the beginning of the yuga by fifteen, and add to the result the number of tithis which have elapsed in addition to the complete parvans; deduct from this sum its sixty-second part; multiply the remainder by two and add to the product sixty-one; divide the result by one hundred and twenty-two; the quotient shows the number of seasons elapsed (which when exceeding six will have to be divided by six, since so many seasons constitute a solar year); the remainder divided by two shows the number of the current day of the current season. This rule seems not very well expressed, although it may be interpreted into a consistent sense. At first it must be remembered that the yuga does not begin with the beginning of a season, but with the month śrávaṇa, while the current season—the rainy season—has begun a month earlier with áshádha. The calculation would hen, strictly expressed, be as follows. Take the number of parvans which have elapsed since the beginning of the yuga, add to it the tithis which have elapsed of the current parvan and add again to this sum $30\frac{1}{2}$ tithis (the tithis of áshádha plus half a tithi of the month preceding áshádha) and deduct from this sum its sixty-second part, *viz.*, the so-called avamarátras, *i. e.*, the lunar days in excess of the natural days (according to the Súryaprajñapti's system each sixty-second tithi is an avamarátra). The remainder of the calculation needs no explanation; the formula enjoins the addition of 61 instead of $30\frac{1}{2}$ and division by 122 instead of 61 (the number of days of a season) in order to get rid of the fractional part of $30\frac{1}{2}$.

In order to find the number of the parvan during which an avamarátra occurs and at the same time the tithi itself which becomes avamarátra, the following rule is given. The question is assumed to be proposed in the following manner. In what parvan does the second tithi terminate while the first tithi has become avamarátra, or in what parvan does the third tithi terminate while the second is avamarátra? and so on, (kasmin parvaṇi pratipady avamarátríbhútáyám dvitíyá samáptim upayáti, etc.) The answer is: if the number of the tithi which becomes avamarátra is an odd one, one has to be added to it and the sum to be multiplied by two; the result shows the number of parvans elapsed before the first tithi becomes avamarátra. If the number is an even one, one is added to it, the sum multiplied by two, and to the product thirty-one is added; the result again shows the

number of parvans elapsed. Thus for instance if it is asked: when does the first tithi become avamarátra? add one to one (number of the tithi) result two; this multiplied by two gives four; therefore pratipad is avamarátra in the fifth parvan, after four parvans have elapsed. Or again it may be asked: when does the second tithi become avamarátra? add one to two; result three; this multiplied by two gives six, to which thirty-one are added. The result—thirty-seven—shows that in the thirty-eighth parvan the second tithi is avama-rátra. Thus all the avama-rátras for the first half of the yuga are found and the same numbers recur during the second half. The rationale of this rule is obvious.

A simple rule is given for finding the tithis on which the ávṛittis of the sun, *i. e.*, the solstices take place. Multiply the number of the solstice whose date you wish to know by 183 and add to the result three plus the number of the solstice; divide this sum by fifteen; the quotient shows the number of parvans elapsed, the remainder the number of the tithi of the current parvan. This rule—being based on the relation of tithis to sávana days needs no explanation. The following list for the whole yuga results from these calculations.

1st Summer solstice (= 10th solstice of the preceding yuga).

	1st	dark	half	of	śrávaṇa.
1st Winter solstice,........................	7th	„	„	„	mágha.
2nd S. S.,..	13th	„	„	„	śrávaṇa.
2nd W. S., ...	4th	light	half	of	mágha.
3rd S. S.,..	10th	„	„	„	śrávaṇa
3rd W. S., ...	1st	dark	half	of	mágha.
4th S. S.,..	7th	„	„	„	śrávaṇa.
4th W. S., ...	13th	„	„	„	mágha.
5th S. S.,..	4th	light	half	of	śrávaṇa.
5th W. S., ...	10th	„	„	„	mágha.

The places which the sun occupies in the circle of the nakshatras at the time of the solstices have been mentioned before; the places of the moon at the same periods can of course be easily calculated when it is remembered that at the beginning of the yuga the moon just enters Abhijit. It is unnecessary to reproduce here the rule given for that purpose; it may only be mentioned that the $\frac{7}{10}$ of a sidereal revolution which the moon performs during one solar ayana in excess of six complete revolutions constitute the "dhruva ráśi" for our case. The Súryaprajñapti likewise states the places in which the lunar ávṛittis take place; from the circumstance that at the beginning of a yuga the moon is full in the first point of Abhijit and at the same time commences her progress towards the north, it follows

that her next progress towards the south takes place exactly on the same spot on which the sun was standing at the beginning of the yuga. At all following lunar ávṛittis the places of the two first ones of course recur.

Incidentally another rule is mentioned which certainly was of frequent application, *viz.*, how to find on what natural day and at what moment of time during that day a given tithi terminates. The rule which is contained in an old karaṇa-gáthá is of course very simple. Add together all tithis which have elapsed from the beginning of the yuga up to and including the tithi in question; divide this sum by sixty-two; multiply the remainder by sixty-one and divide again by sixty-two. The remainder is then the wanted quantity. The first division by sixty-two has the purpose to shew by its quotient—the number of complete avamarátras elapsed since the beginning of the yuga; this number has therefore to be deducted from the number of tithis elapsed. The remainder of the above division shows the number of tithis which have elapsed since the occurrence of the last avamarátra; to find by how much they remain behind the same number of natural days, they are multiplied by 61 and divided by 62 (61 natural days = 62 tithis); the remainder then indicates how many sixty-second parts of the current natural day have elapsed at the moment when the tithi in question terminates.

Another old rule has the purpose of teaching how to find the number of muhúrtas which have elapsed on the parvan-day at the moment when the new parvan begins. When the number of the parvan divided by four yields one as remainder (in which case it is called kaly-oja) we must add ninety-three to it; if divided by four it yields two (in which case it is called dvápara-yugma), we add sixty-two to it; if it yields three (tretá-oja), we add thirty-two; if there is no remainder (kṛita-yugma), we add nothing. The sum which we obtain in each case is halved, then multiplied by thirty, finally divided by sixty-two. The quotient shows the number of muhúrtas of the parvan-day which have elapsed at the moment when the new parvan begins. The rationale of this rather ingenious rule is as follows. The duration of one parvan is $14\frac{94}{124}$ days. The first parvan therefore terminates when $\frac{94}{124}$ of the day $= \frac{94 \times 30}{124} = \frac{47 \times 30}{62}$ muhúrtas have elapsed. The number 94 may be obtained by adding 93 to 1, the number of the first parvan. The second parvan ends $29\frac{64}{124}$ days after the beginning of the yuga; 64 equals $62 + 2$, the number of the second parvan. The third parvan terminates $44\frac{34}{124}$ days after the beginning of the yuga; 34

equals 31 + 3, the number of the third parvan. The fourth parvan terminates 59 $\frac{4}{124}$ days after the beginning of the yuga; 4 without any addition is the number of the parvan. The fifth parvan again terminates 73 $\frac{98}{124}$ days after the beginning of the yuga; 98 is equal to 93 + 5, the number of the parvan. And so on through the whole yuga.

The above examples fairly represent the more important rules contained in the Súryaprajñapti. Now it will be apparent to every one who is to some extent familiar with the Jyotisha-vedánga* that the rules contained in the, as yet partly unexplained, verses of the latter refer to calculations exactly analogous to those contained in the Súryaprajñapti and the old gáthás quoted by the commentator.

From this it might be concluded that it is now easy for us to explain whatever has up to the present remained unexplained in the Vedáñga, possessing as we doubtless do a clear insight into the general nature of the calculations for which it furnishes rules. But close as the connexion between the contents of the two treatises manifestly is, there are two reasons which preclude the direct application of the rules of the Súryaprajñapti to the elucidation of the Vedáñga. In the first place the Vedáñga divides the sphere into twenty-seven nakshatras only and, as far as has been ascertained up to the present, these twenty-seven nakshatras are considered to be of equal extent; while as we have seen above the Súryaprajñapti throughout employs the division of the sphere into twenty-eight nakshatras of unequal extent. In the second place the starting point for all calculations (*viz.*, the places of the winter and summer solstice) is not the same in the two works. The consequence of these two fundamental discrepancies is that although the questions treated of are essentially the same and although the modes of calculation are strictly analogous the results arrived at in the two treatises necessarily differ in all cases, that for instance the place of a certain full or new moon during the quinquennial yuga can never be the same according to the Súryaprajñapti as it is according to the Vedáñga, etc. Nevertheless it is highly probable that somebody who should apply himself to the study of the obscure portions of the Vedáñga after having made himself thoroughly conversant with the contents and methods of the Súryaprajñapti, would succeed in solving some more of the riddles presented to us by the former work.

* Since the publication of the paper on the Jyotisha-vedáñga in the 46th volume of this Journal, the writer has received some very important contributions to the explanation of the Vedánga from Dr. H. Oldenberg, the well-known editor of the Vinayapiṭakam, who working altogether independently had succeeded in explaining a number of hitherto obscure rules. The writer intends to revert to the Vedánga before long and will then avail himself of the new results most kindly placed at his disposal by Dr. Oldenberg.

It must be remembered that there is no indissoluble connexion between that part of the system of the Súryaprajñapti, which might be called the chronometrical one, *viz.*, the doctrine of the quinquennial yuga and its various subdivisions and that part which propounds the theories accounting for the apparent motions of the sun and the moon; it might therefore be that the Vedáñga agrees with the Súryaprajñapti only in the former point and follows a different course with regard to the latter. There occurs, however, one expression in the Vedáñga which makes it appear likely that the analogy between the two books extends to the second point also, *viz.*, the "súryamaṇḍaláni" mentioned in verse 22.

अतीतपर्वभागेभ्यः शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ॥

It certainly looks as if by these "sun circles" in which the sun is said to be at the end of a tithi, we had to understand daily circles of the same kind as those which, according to the Súryaprajñapti, the sun describes round Mount Meru.

A few words may here be added on the principal feature common to the cosmological systems of the Puráṇas, Buddhists and Jainas, *viz.*, the doctrine of sun, moon and constellations revolving round Mount Meru. In order rightly to judge of these conceptions we must remember that they arose at a time when the idea of the sphericity of the earth had not yet presented itself to the Indian mind, at a time (—if we may assume that the Puráṇic-Buddhistic cosmological system is not later than the period of the rising of Buddhism—) when this then truly revolutionary idea first suggested itself to the early Greek philosophers. And if we carry our thoughts back to that early stage of the development of scientific ideas and try to realize the conceptions which then were most likely to present themselves to enquirers, the old Indian system will lose much of its apparent strangeness and arbitrariness. How indeed could men ignorant of the fact that the earth is a sphere freely suspended in space explain to themselves the continually recurring rising and setting of the heavenly bodies? what could their ideas be regarding the place to which sun and moon went after their setting, and the path which unseen by man they followed so as to return to the point of their rising? Certainly the difficulty was a very great one to those as well who had some vague notion about the earth extending in all directions to an unlimited distance as to those who imagined it to be bounded at a certain distance by a solid firmament surrounding and shutting it in on all sides. We may recall, as one of the fancies to which the difficulty of this question gave rise, the old poetical idea, pre-

served, for instance, in a beautiful fragment of Stesichorus, of Helios when he has reached Okeanos in the west embarking in a golden cup which carries him during the night round half the earth back to the east whence he rises again. Under these circumstances we must admit that the old Indian idea of the constitution of the world, according to which the rising and setting of sun, moon and stars is only apparent, cannot by any means be called an unnatural one, and it is interesting to consider the counterparts it finds among what is known of the opinions of the oldest Greek philosophers.* So it is reported of Anaximenes that he supposed the sun not to descend below the earth, but to describe circles above it and to pass during the night behind high mountains situated in the north; an exact parallel to the Indian conception. Of Xenophanes we hear that he declared the sun, moon and stars to be only accumulations of burning vapour, fiery clouds kindling and extinguishing themselves by turns, that these clouds move in reality in straight lines and only appear to us to rise and to set in consequence of their varying distance, in the same way as the common clouds seem to rise from the horizon when they first become visible to us and seem to sink under the horizon when they pass out of our field of vision. These opinions too find their exact counterpart in the Súryaprajñapti and kindred works where the rising and setting of the heavenly bodies is declared to be an appearance caused by their consecutive approaching and receding, and where their movement is said to take place not indeed in a straight line but at any rate in a plane parallel to the plane of the earth. The first mentioned opinion of Xenophanes about the constitution of the heavenly bodies finds its analogon in one of the different pratipattis, mentioned in the Súryaprajñapti, according to which the sun is nothing but a "kiraṇasaṃgháta," an accumulation of rays forming itself every morning in the east and dissolving itself in the evening in the west. The cognate views held by Heraclitus concerning the nature of the sun are well known. Of Xenophanes it is further reported that he supposed different climes and zones of the earth, far distant from each other, to have different suns and moons; which is another striking parallel to the view held by the Jainas with reference to the different suns, moons and stars illuminating the different concentric dvípas of which the earth consists. In both cases the assumption of the rising and setting of the heavenly bodies being an appearance, caused by their becoming visible and invisible in turns when having approached us or receded from us by a certain amount, seems to have lead to the conclusion that the light of the one sun and the one moon appearing to us cannot illumine the whole vast earth, since it only reaches to a certain limited

* For the particulars mentioned in the following: comp. Mullach's collection of the fragments of the Greek philosophers, Zeller's history of Greek philosophy, Lewis's historical survey of the Astronomy of the Ancients.

distance.—On the other hand it is true enough that, notwithstanding these similarities of Indian and Greek ideas, books of the nature of the Súryaprajñapti serve clearly to show the difference of the mental tendencies of the two nations. Both in an early age conceived plausible theories, in reality devoid of foundation, by which they tried to account for puzzling phenomena; but while the Greeks controlled their theories by means of continued observation of the phenomena themselves and replaced them by new ones, as soon as they perceived that the two were not in harmony, the Hindus religiously preserved the generalisations hastily formed at an early period, and instead of attempting to rectify them, proceeded to deduce from them all kinds of imaginary consequences. The absurdity of systems of the nature of the Jaina system lies not in the leading conceptions—these can as a rule be accounted for in a more or less satisfactory manner—but in the minute detail into which the followers of the system have without scruple and hesitation worked it out.

Before this paper is brought to a conclusion, the writer wishes to draw attention to the—in his opinion very striking—resemblance which the cosmological and astronomical conceptions, contained in an old Chinese book, bear to the early Indian ideas on the same subject, more particularly to the Jaina system as expounded in the Súryaprajñapti. The Chinese book alluded to is the Tcheou-Pei of which a complete translation was published for the first time by Edward Biot in the Journal Asiatique for 1841, pp. 592—639. It consists of two parts of different ages; the first part which apparently is of considerable antiquity, has been known since the time of Gaubil, who inserted a translation of it into his history of Chinese astronomy, published in the Lettres éd fiantes; that part, as is well known, shows that the ancient Chinese were acquainted with the theorem about the square of the hypothenuse of a right-angled triangle. The second and more recent part, which E. Biot thinks cannot be later than the end of the second century of our era, contains a sort of cosmological and astronomical system, and here the traits of resemblance alluded to above are to be found. As the arrangement of topics in the Tcheou-Pei is by no means systematic, so that it is not easy to form a clear conception of the essential points, a short abstract of the work, as far as it lends itself to a comparison with the Jaina system, is given in the following.

According to the Tcheou-Pei the sun describes during the course of the year a number of concentric circles of varying diameter round the pole of the sky. On the day of the summer solstice the diameter of this circle is smallest; it then increases during the following months, up to the day of the winter solstice when it reaches its maximum. Beginning from this day the solar circles again decrease, until on the day of the next summer

solstice they have reached the original minimum. On the day of the winter solstice the diameter of the solar circle amounts to 476,000 li (the li is a certain Chinese measure of length); its circumference to $3 \times 476,000 =$ 1,428,000 li. The corresponding numbers for the circle, described on the day of the summer solstice, are 238,000 and 714,000. Between the innermost and the outermost circle there lie five other circles, which the sun describes in the months intervening between the two solstices, so that there are altogether seven circles; the six intervals between these are said to correspond to the months of the year ($2 \times 6 = 12$). So it appears that the Tcheou-Pei assumes separate solar circles for each month only, not for each day. Each circle is at the distance of $19,833\frac{1}{3}$ li from the two neighbouring circles.

The terrestrial place for which all the calculations of the Tcheou-pei are made is said to have such a situation that it is distant 16,000 li from the spot lying perpendicularly under the sun on the day of the summer solstice and 135,000 li from the spot lying perpendicularly under the sun on the day of the winter solstice; the distance of the place of observation from the pole, *i. e.*, the spot at the centre of the earth which lies perpendicularly under the celestial pole, is said to amount to 103,000 li. Round the terrestrial pole there extends a circle of 11,500 li radius, which is the terrestrial counterpart of the circle described by the polar star round the celestial pole. The light of the sun extends 167,000 li in each direction, so that on the day of the winter solstice when the sun moves in the exterior circle it extends at midday only 32,000 li beyond the place of observation and so does not reach up to the polar circle. On the days of the two equinoxes when the sun is moving in the fourth circle—the diameter of which amounts to 357,000 li—the rays of the sun just reach up to the polar circle. On the day of the summer solstice when the sun moves in the interior circle his rays reach beyond the pole to the extent of 48,000 li, so that then the whole polar circle is continually illuminated. When the sun in his daily revolution has reached the extreme north point, it is midday in the northern region and midnight in the southern region; when he has reached the east point, it is midday in the eastern, midnight in the western region; when he has reached the south point, it is midday in the southern, midnight in the northern region; when he has reached the west point, it is midday in the western, midnight in the eastern region. As the light of the sun always reaches 167,000 li each way, we must add $2 \times 167,000$ to the diameter of the circle, described on the day of the winter solstice, in order to obtain the diameter of the circle representing the outmost limit reached by the rays of the sun; the diameter of this circle is therefore 810,000 li.

On the day of the winter solstice the space illuminated by the sun

stands to the space not reached by his rays in the relation of three to nine; this proportion is to be reversed for the day of the summer solstice. The day of the winter solstice is the shortest during the year; the day of the summer solstice the longest. On the day of the winter solstice the shadow of the gnomon is 13·5 feet long; beginning from this day it goes on diminishing by equal quantities during equal spaces of time up to the day of the summer solstice when its length is reduced to 1·6 feet. It then increases again in the same uniform manner up to the day of the next winter solstice.

The circumference of the sky is divided into twenty-eight stellar divisions of unequal extent, through the circle of which sun and moon are performing their revolutions. Kien-nieou is the asterism in which the sun stands at the winter solstice; Leou the asterism of the vernal equinox etc. A procedure is taught how to find the place of the sun at any time. The whole circle of the asterisms is divided into $365\frac{1}{4}$ degrees corresponding to the number of the days of the year. A year is the period which the sun requires for returning to the same star from which he had set out. The meeting of sun and moon constitutes a month. A period of nineteen years of $365\frac{1}{4}$ days each contains 235 lunations. Arithmetical rules are given how to find the place of the moon at the beginning of each year etc.

The Tcheou-pei contains some additional matter about observations of the polar star etc., but by far the greater part of the topics it treats have been touched in the above summary. The similarity of this system and the old Indian systems particularly, as far as some details are concerned, the Jaina system is obvious. The same supposition is made use of in both to account for the alternating progress of the sun towards the north and the south. In the Jaina system the sun revolves round Mount Meru, in the Chinese system, to which the idea of a central mountain seems to be foreign, round the pole of the sky; Mount Meru finds, however, a curious counterpart in the Chinese polar circle, the projection of the circle described by the polar star. Both systems state the dimensions of the circles described by the sun; both state in figures the extent to which the rays of the sun reach. Both hold the same opinion about the alternation of day and night in the different parts of the earth. Both are interested in finding out what places sun and moon occupy in the circle of the nakshatras. Both teach the increase of the shadow by an equal quantity in each month. On the other hand there are important points in which the two systems differ. The Chinese appear from comparatively ancient times to have had a knowledge of the fact that the approximate duration of the solar year amounts to $365\frac{1}{4}$ years and that a period of nineteen years comprises 325 lunations. This of course makes the system of the Tcheou-pei to differ from the Jaina system in all those details which depend on the fundamen-

tal period and the advantage is of course altogether on the side of the Chinese. On the whole the Tcheou-pei is much superior to works of the stamp of the Súryaprajñapti, as in midst of all the fantastical and unfounded ideas it contains there are found some positive elements, observations of stars which admit of control etc., features altogether absent in the Súryaprajñapti. But in spite of these points of difference the similarities of the two works remain striking, especially if we take as one member of the comparison not the Súryaprajñapti itself but some hypothetical older work of the same class, less elevate and more moolerate in the statement of dimensions, figures etc. That such works if not existent at present must have existed at same earlier period is manifest from the remarks the Súryaprajñapti in many places makes about the opinions of other teachers, several of which have been extracted above. That two different chronological periods, the quinquennial yuga and so called Metanic cycle, from the foundation of the two systems does after all not interfere very much with their similarity. We might imagine the Jainas adopting the more correct cycle of nineteen years instead of the quinquennial one and work out all the new details necessitated by such a change, calculate all the places of moon and full moon during nineteen years instead of five etc., nevertheless the new system would immediately suggest the idea of the old one. An essential feature in the resemblance of the Chinese and the Hindu system is more over the circumstance of both limiting themselves to the treatment of a certain number of topics. The following paragraph of the Tcheou-pei (p. 603) which shortly states the questions to be treated in the work, might with hardly any change be taken as a summary of the contents of the Súryaprajñapti.

"I have heard people speak of the knowledge of the great man. I have heard it said that he knows the height and the size of the sun, the extent which his light illuminates, the quantity by which he moves in the course of one day, the quantity be which he recedes and approaches, the extent which the eye of man embraces, the position of the four extreme (cardinal) points, the divisions of the stars arranged in order, the breadth and length of the sky and the earth."

The questlon whether the similarity of the two systems justifies us in assuming a historical connexion between the two or would be an interesting one, but cannot be treated in this place, especially as its solution could only be attempted together with the solution of a number of cognate problems.

Coins supplementary to Thomas' "Chronicles of the Paṭhán kings of Delhi."—By Chas. J. Rodgers. (With a Plate.)

Steady research is always followed by constant results. These results are as a rule insignificant discoveries which are individually small, but collectively they all go to swell the sum of human knowledge. In my last small supplement to Thomas' "Chronicles of the Paṭhán kings of Delhi" I promised to give some additions which I had then in hand. But as I went on with two other papers and my researches for them, I found that incidentally my matter for the second supplement grew more interesting, and at last I found to my surprise that I had more coins in hand than would fill two plates; so I began to draw at once and simultaneously to put away for a third supplement all coins for which I could not now find a place. Strange to say just as I had made up my mind about these plates a find of about 500 coins of five Ghazni kings, all struck at Lahore, came to hand, some quite new and unpublished, and after that a batch of silver coins of Ala-uddin Khwárizmí of whose coins I gave three new types in my first supplement and of whose I give one great beauty in my present paper. These silver coins were struck at *Ghazní* and *Farwán* or as Thomas calls it '*Perwán.*' He gives no drawings of them and only alludes to them as giving us the mint of Perwán. These Ghazní kings' and the Khwárizmí king's coins must stand over for the present. I scarcely dare make a promise about them. About a year ago I came across a find of Ghazní coins, in number about 500, and up till now I have had no time to work at them and say what was in them, although there were several novelties of historic value. As I personally go to the bazars I see for myself what comes into them. And when I see what comes into them and what finds a lodgement in our museums, I am astonished and dumb-foundered to think that coins of whose existence we are unaware are daily being brought in from the villages and fields and ruins which abonnd here and there in the country and are simply handed over to the smelting pot as common silver,—bullion in fact which is purchased at a little less than its intrinsic value. And all this, while there is in India no Imperial Cabinet of Coins and no one appointed to collect for it and arrange it and make it a thing worthy of the historical associations, India as an Empire and as a collection of ancient kingdoms and states, possesses. India is a continent: but it is too poor to possess one Imperial Cabinet of coins which would serve as a metallic record of past emperors and rulers, past glories and shames, in fact, which would be a history of the past in metal manuscripts. With the present rage for melting down