

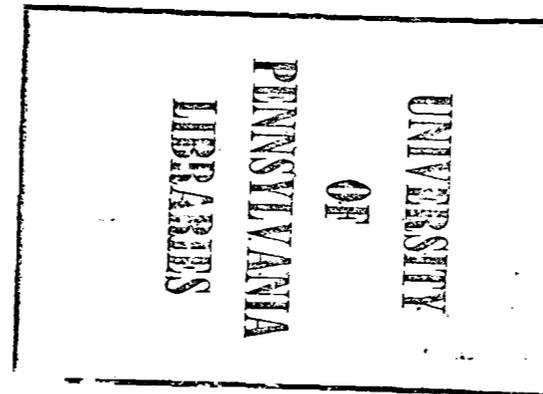
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[YANTRAS OR MECHANICAL
CONTRIVANCES IN ANCIENT INDIA]

By

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TRANSACTIONS

Many valuable lectures are given, papers read and discussed, and oral reviews of outstanding books presented, at the Indian Institute of Culture. Its day is still one of small beginnings, but wider dissemination of at least a few of these addresses and papers is obviously in the interest of the better intercultural understanding so important for world peace. Some of these are published in the Institute's monthly organ, *The Aryan Path*; then we have two series of occasional papers—Reprints from that journal, and Transactions. The Institute is not responsible for views expressed and does not necessarily concur in them.

Transaction No. 10

Dr. V. Raghavan heads the Department of Sanskrit in the University of Madras. He came to Bangalore to deliver two lectures, on June 18th and 19th, 1951, under the auspices of the Indian Institute of Culture. It is the first of these, given under the chairmanship of Prof. D. D. Kosambi, which we publish here.

Dr. Raghavan's paper admirably complements Dr. H. J. J. Winter's study: *The History of Scientific Thought with Special Reference to Asia*, published as the Institute's Transaction No. 5.

His careful study of this subject has led him to conclusions about ancient India quite different from the stereotyped concept popular in the West. The idea of a nation of dreamers, essentially impractical folk, is one which has never been reconcilable with the surviving records of engineering triumphs and the rare achievements in architecture as well as in art which have defied the ravages of time and climate through untold centuries. The intellectual, moral and spiritual heights attained by ancient India's great seers and sages, to which early writings and far earlier oral traditions bore witness, were generally recognized in India. With that recognition may have gone a growing undervaluation of material development that may have played its part in the neglect for ages to carry further, on the practical side, the high material civilization attained thousands of years ago, to which the very ancient ruins of Mohenjo-daro bear witness.

The explanation for the loss of ancient technological knowledge advanced by another scholar, Shri V. R. R. Dikshitar, the author of *War in Ancient India*, is the secrecy with which certain arts and sciences were guarded, lest, he believes, the popular knowledge of them lead to abuse and disturb the peace of mankind. Certainly the modern world can appreciate the value of such a sense of responsibility in the possessors of dangerous knowledge!

But, whatever the cause of the material decline, Dr. Raghavan as well as Shri Dikshitar is convinced by the textual evidence that ancient India had once attained a high technological development, even in aeronautics.

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YANTRAS OR MECHANICAL CONTRIVANCES IN ANCIENT INDIA

"To deny to Babylon, to Egypt and to India, their part in the development of science and scientific thinking is to defy the testimony of the ancients, supported by the discovery of the modern authorities." L. C. KARPINSKI.¹

"Thus we see that India's marvels were not always false." LYNN THORNDIKE.²

It is indeed in the realms of literature and art, religion and philosophy that ancient India made its outstanding contributions. While the achievements in the former have gained world-wide appreciation, those in the latter constitute really the survival value, if any, of the ancient culture of this country. The skill of execution evident in art, the speculation that fathomed the depths of the spirit, and the powerful imagination that was an over-all feature of all this activity, expressed themselves so freely, however, that no bounds were set to the all-round unfoldment of this culture, and the fecund creative power resulted in unceasing zest in every department of intellectual activity. The exclusive other-worldliness of this culture is no longer subscribed to,³ and the discovery of manuscripts and the advance of research have both brought to light no insignificant amount of ancient Indian activity in the fields of positive aspects of life, of subjects of practical interest and scientific value, which, considering the intellectual level of other nations in those times of antiquity, do justify India's claim to the role of teacher of the ancient world.

On this positive side of ancient Indian culture, topics pertaining to major sciences like medicine or mathematics have always formed the recognised subjects for research or disquisition. I have picked up an out-of-the-way subject from what may be referred to as one of the byways in this department of investigation. The enormous scientific advancement today and our familiarity with marvels of mechanical invention and perfection may reduce the value of this study; but it must be granted by the moderns that it is the dreams of ages and the crude experiments of old that have been the forerunners of the recent advances.⁴

¹ His article "Hindu Science," *The American Mathematical Monthly*, 1919, Vol. xxvi, pp. 298-300; quoted by LYNN THORNDIKE in his *History of Magic and Experimental Science*, Six Volumes. (New York, 1923 ff.)

² THORNDIKE, *op. cit.* Vol. II. p. 238.

³ See the present writer's "Is Hindu Culture Other-worldly?" *The Twentieth Century*, Allahabad, 1937, August, pp. 1142-1154; September, pp. 56-65; October pp. 169-179.

⁴ It may be interesting in this connection to draw attention to the story of the 8th century Jain writer Haribhadra and his two nephews, Hamsa and Paramahamsa, as told

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To a student of ancient Indian civilization in detail this is a question arousing very keen enthusiasm and, from the point of view of the general cultured public conversant with Sanskrit literature, what I am going to present contains much unfamiliar material about which they are likely to be curious. The whole of this material has not, so far as I know, been set forth previously at length or in a single place; the literary sources concerned are not free from textual problems and difficulties of interpretation, a few of them being still in manuscript; and, on the whole, I feel gratified, and grateful to this Institute that I have this opportunity to put together data that I have been noting down for some time.

That from ancient times the idea of a *yantra* was very common is proved by two facts, the application of the concept to the esoteric sphere, and the way the *yantra* roused the imagination of the spiritual writers. In esoteric worship the *yantra* was a chart which stored up within its confines spiritual power; drawn on a flat surface or made in relief, it had components or details which had to be strictly conformed to and, as an instrument for achieving spiritual power, it eminently deserved the name "yantra." In the minds of the writers, who were essentially men of religious faith and spiritual yearning, the *yantra* or machine always suggested a highly apt analogy for the material universe or the mundane body activated by a God or presided over by a Soul.

The word "yantra" is derived from the root *yam*, to control, and has been freely used in ancient India for any contrivance; some very simple ones are commonly known: the water-pulley in the well was called *Ghaṭīyantra*; an oil-presser was *Taila-yantra*; a cane-presser was *Ikshu-yantra*; ploughs, water-lifts and even weighing balances were referred to as *yantras* (*Arthaśāstra* II. 19; II. 24); and in Tamil even the stone grain-grinder is referred to by the Tamil form of the same name "entiram." These should not lead us to think that very complicated mechanisms were not evolved by the ancients.

Mechanical skill had produced in ancient India many accessories for scientific activities, such as surgical instruments in medicine, the *pākayantras* or laboratory equipment in medicine, *Rasāyana*, and the astronomical *yantras*⁵ described in *Jyotiṣa* works. These belong to a different category. Nor do I propose to touch upon very late material, when Sanskrit writers translated or reproduced from Persian works, as for instance the *Bhārothhāpana-yantra-nirmāṇa* on weight-

in the *Prabhavakacarita* (ix. 48 ff.) where we hear of the employment of a *parachute* for escaping. The nephews were confined in an upper storey by their angry Buddhist teacher and, to escape further punishments, the brothers spread two umbrellas, jumped out of the window, and softly and safely set foot on the ground. (*Ibid.*, Ch. ix, verses 87-89)

⁵ See *Indian Historical Quarterly*, "Astronomical Instruments of the Hindus," Vol. IV, pp. 256-269.

lifting contrivances, a 17th century work, translated by Devasimha according to his own statement, from a Persian work.⁶

The *yantra* as I shall take it here derives much of its interest from the social background and I, therefore, crave your indulgence for presenting here a whole picture of it, together with its proper *milieu*.

One of the best creations of the most ancient architects of this country is the chariot, *Ratha*. The *Ratha-kāra* of Vedic times was ever a person of importance, according to the *Vājasaneyi-Samhitā*, the *Śathapatha-Brahmana* and the *Atharva-veda*. To the earliest Vedic poet the *Ratha*, finely hewn and fitted, was the very type of a well-wrought thing; his appreciation of the skill involved in its making made him not only refer to its maker as a person of high mental equipment, *Dhīra* and *Maniṣin*, but several times compare himself and his own creation in words, the hymn, to the gifted carpenter shaping his chariot. (*Rigveda*, I. 130.6; V. 2. 11; 29. 15; 73. 10; X. 39. 14). The poet referred to himself as a *Kāru*, architect; later, the Great Epic refers to the architect *Maya* as a *Mahākavi*, a great poet.

The *Ribhus*, *Viśvakarman* and *Tvashtar* of the Vedas and the anonymous Vedic *Takshan* are succeeded in the epics by the two great architects of the Devas and the Asuras, *Viśvakarman* and *Maya*. The epics form indeed the great age of the exploits of *Viśvakarman* and, even to a greater extent of *Maya*.⁷ Both the epics are full of the magnificence of the architecture for which *Maya* was responsible. In the *Mahābhārata* we hear of the *Matsya-yantra* or the revolving wheel with a fish which *Arjuna* had to shoot in order to win *Draupadī* in the *svayamvara*. This has a late echo in the *Gadyacūḍāmaṇi* and *Kṣhatracūḍāmaṇi* of the Jain poet *Vādībhasimha* of the 12th century, in a similar context of *svayamvara*, the test stipulated here being the piercing of three boars placed within a *yantra* called *Candraka-yantra*. In this connection attention may be drawn also to the general observation in both *Kauṭilya* and *Kālidāsa* that one of the uses of the hunt is to develop the skill to shoot targets which are in constant movement (*paricayam cala-lakshya-niṣātane*).

In *Ādi* 64 (Kumbhakonam edition), the *Mahābhārata* describes the festival of *Indra's banner* inaugurated by *Uparicara Vasu*, which thereafter continued to be celebrated as a great national festival, by the Kings especially. The *Rāmāyana*, which refers to *Indra's Banner* more than once, takes it specifically as a *yantra-dhvaja*. The *Flagstaff* representing *Indra* was an elaborate affair, with a large number of things hanging about it all around, and its raising and

⁶ *The Poona Orientalist*, Vol. X. 3-4 (July-Oct. 1945), pp. 79-80.

⁷ *Journal of the Royal Asiatic Society* (London) 1915, pp. 77-83.

bringing down after a 10-day festival were impressive sights. The falling down of Bharata in *Ayodhya* 77.9 is compared to the *yantra-dhvaja* of Indra falling down. That the flag was raised and pulled down by means of fittings and ropes is known from another reference, in the *Yuddhakāṇḍa*, where Rāma and Lakshmaṇa lying down in Indrajit's *Nāgapāśa* are compared to the Indra-banner after the ropes have been let loose. The full particulars of the erection and dismantling of the *Indradhvaja* are set forth by Bhoja in a chapter of over 200 verses exclusively devoted to it in his *Samarāṅgaṇasūtradhāra*. The central pole, the pedestal, the painted flag itself, the subsidiary fittings, the dolls to be hung on it, its outstretched arms, the six ropes attached to it and several *yantras* fitted to it for raising it and bringing it down are described by Bhoja. In the *Harivamśa*, a supplement to the *Mahābhārata*, there is mention of the stone-throwing machine, *Aśma-yantra*, in the battle with Jarāsandha (II. 42. 21).

More interesting references are made by Vālmiki to *yantras* on the field of battle, the continuity of which tradition we see later in the *Arthaśāstra* of Kauṭilya. The fortifications include equipment in the form of *yantras*. In *Ayodhya* 100.53, in the *Kaccit-sarga*, while enquiring about measures of defence, Rāma asks Bharata whether the fort is equipped with *yantras*. Laṅkā, as a city built by Maya, is naturally more full of the *yantras*. The city, personified as a lady, is called *yantra-agāra-stanī*, informing us of a special chamber filled with *yantras*. (*Sundara* 3. 18). In his account to Rāma of the fortifications of Laṅkā, Hanumān says in *Yuddha* 3.12 that Laṅkā has four big gates and that each gate is furnished with strong and huge *yantras* that can hurl both arrows and stones (*Upala-yantras*):

तत्रेषूपलयन्त्राणि बलवन्ति महान्ति च ।

And over the moats are bridges which are controlled by numerous big *yantras* (3.16, 17). That such *yantras* were employed on the field is seen in a description of Kumbhakarṇa, in *Yuddha* 61.32, where his giant figure striding the streets of Laṅkā is compared to a huge *yantra* that has been set up:—

उच्यन्तां वानराः सर्वे यन्त्रमेतत् समुच्छ्रितम् ।

Mammoth machines turned by a large number of persons and making a terrific noise are to be seen in a description of Rāvaṇa, soon after he got the news of Indrajit's death. As he gnashed his teeth in fury, the noise was heard as of a big catapult being turned by Dānavas.

• दन्तान् विदशतस्तस्य श्रूयते दशनस्वनः ।

यन्त्रस्यावेष्टयमानस्य महतो दानवैरिव ॥ VI. 93.23.

The mention here of Dānavas in connection with machines must be noted. Later we see references to machines, associating the Yavanas especially with

them. The reference gains some significance when we bear in mind the relation of Maya with the Asuras and of the Asuras with Iran⁸ and the near west, and the continuous contact which ancient India had with these neighbouring and cognate civilizations on the west.

The *Arthaśāstra* of Kauṭilya is one of the books of culture which throw a flood of light on the particular epochs in which they arose. This work of c. 300 B.C. being a treatise on statecraft, speaks of *yantras* in connection mainly with battles, but also with architecture to some extent. An early work, a theoretical treatise and a text of great reputation, the *Arthaśāstra* forms our most valuable document on the subject of *yantras*.

Before we come to its account of the main *yantras* of warfare, we shall note some of the other mechanical contrivances met with in Kauṭilya's work. In II. 5, he refers to a dugout, *Bhūmigrīha*, and mentions for it a mechanical staircase which can be thrown in and withdrawn (*Yantra-yukta-sopāna*). While detailing the exact methods to be adopted for finishing off enemies and unwanted persons (XII. 5), Kauṭilya speaks of machines which could be conveniently pressed into service. When the unwanted person is entering a temple, from an overhead *yantra* there could be released on his head a piece of masonry or a stone to kill him instantly.

It may be recalled here that in the political play of Viśākhadatta in which the author of the *Arthaśāstra* is the leading character, Kauṭilya is made to use this device against Vairocaka, brother of Parvatakeśvara, the unwanted partner; Kauṭilya gets advance intelligence of the ruse employed by Rākshasa through an architect named Dāruvarman; the architect had erected a *yantra-toraṇa*, a mechanically fitted arch, which could be brought down by the drawing out of one of the fastening rods; this had been set up to kill Candragupta as he entered the palace for the coronation; and Kauṭilya offers Vairocaka as a victim to this *yantra-toraṇa*. This may be compared to the *Viśvāsa-ghāti* to be noticed below. A second ruse mentioned by Kauṭilya for the same purpose is a bedchamber in which part of the flooring has a mechanical contrivance; underneath this part of the floor is a deep cavity or a pit with pikes; and over it is placed the bed of the unwanted person; after he goes to sleep, the flooring is released and down goes the poor man with his bed.

⁸ See D. B. SPOONER, "The Zoroastrian Period of Indian History," (*J. R. A. S.* 1915, pp. 63-89, 405-455); the theory of Persepolitan influence in Mauryan architecture is worked out here. On Asura Maya as Ahura Mazda, see *ibid.*, pp. 80-89. See also Archaeological Report, Government of India, 1912-13; 1913-14. GRUNDWELL and BURGESS, *Buddhist Art in India*, p. 17. On Persepolis as a channel of influence and contact between India and Assyria, see KENNEDY, "Early Commerce of Babylon with India, 700-300 B.C.," *J. R. A. S.* April 1898, p. 283.

Yantras for actual warfare are generally touched upon in several contexts: II.3 and 18 mention the need to equip forts with yantras. In X. 4, yantras on the field are said to be attended to by special labourers and workers. In IX.2, Kauṭilya deals with counter-manceuvres for tackling particular kinds of enemy forces; here, among the things to be used against elephants yantras or probably *Hasti-yantras* are included; these are machines in general or special machines designed to scare elephants; Bhoja, in his *Samarāṅgaṇasūtradhāra*, mentions that one of the uses of the aerial vehicle is to create a terrific noise and frighten elephants. In XIII.4, Kauṭilya advocates the use of yantras for devastating an enemy place which is full of defence-erectations.

The chapter devoted wholly to armoury, *Āyudhāgāra*, II.18, is the main section speaking of military yantras. Kauṭilya divides the yantras into stationary and mobile—*Sthira* and *Cala yantras*. The former class comprises:—

Sarvatobhadra: According to the commentary of Bhaṭṭasvāmin⁹, this is a sharp-edged wheel that is placed on a wall and rotated so as to fling big stones all around; according to others, it is also called *Siddhabhūmirika-yantra* and scatters small stones.

Jamadagnīya: Bhaṭṭasvāmin explains it as a big *Śara-yantra* or mechanical arrow-thrower. It is placed behind a wall and it shoots arrows through crevices in the wall. But the name signifies a fire-arm.

Bahumukha: This is an elevation and a mount for archers; it is leather-covered and is as high as the wall to enable archers to shoot all round.

Viśvāsaghātī: An iron bar placed across the path in the approaches to the city, which, manipulated by a mechanical device, falls down and pounds a man. It belongs to the class mentioned above for killing unwanted persons and the *yantra-toraṇa* mentioned in the *Mudrārākshasa*.

Sanghāṭī means "tied together". It was made of wood and used to set fire to enemy fortifications. It is called an *Agni-yantra*.

Yānaka or *Yānika* is a yantra moved on wheels; it discharges batons.

Parjanya is an *Udaka-yantra*, a fire-quencher.

Bāhus are two arm-like pillars which when released from either side by a yantra, press to death a person between them; this appears to be an instrument of torture.

Ūrkhvabāhu is similarly an overhead column which comes down upon a man and puts him to death.

⁹ Printed in the *Journal of the Bihar and Orissa Research Society*, XII, pt. 1, Supplement, p. 105 ff.

Ārdhābāhu is the same as *Bāhu*, but is of diminutive size.

The *Cala-yantras* are:

Pāñcālīka. Its use is outside the fort walls, in the moat; thrown in the midst of the water, its sharp protruding points prevent the progress of enemies.

Devadāṇḍas are long cylindrical cannon-like things placed on parapet walls. Bhaṭṭasvāmin gives them another name also, *Pratitaroca*.

Śūkarikā is a huge thing shaped like a pig or bellows, made of bamboo, rope and hide, filled inside with cotton etc., and is placed on the path as an obstruction and as a buffer to stop stones, etc., that are flung by the enemy. According to some others, *Śūkarikās* are to prevent enemies from easily getting up the ramparts; they, on this view, were probably closely suspended all along the walls to prevent the enemy-scaler from getting a foothold.

Musala and *Yashti* are well-known; *Hastivāraka* is interpreted as a two- or three-pronged iron rod, *Hastiparigha*, for striking at elephants, but may really mean, as seen from a reference in Daṇḍin's *Avantisundarī*, a machine which hurls heavy iron rods to smite and demoralize the elephants.

A *Tālavrinta* mentioned is explained as a *Vālacakra*, the significance of which is obscure. We may suggest that here was a device to create a tempest which could demoralize the enemy ranks. The observation of Philostratus, relating to Alexander's invasion of India; that Indians drive the enemy off "by means of tempest and thunders, as if from heaven,"¹⁰ may, however, be only an echo of the epic *Vāyavya-astra*.

After *Mūḍgara*, *Gadā*, *Sphrikṭalā*, a picked missile, and *Kuḍḍāla*, are mentioned in the following:—

Āsphoṭīma has four feet, is covered by hide, has a projectile and throws stones.

Udghāṭīma is a machine which demolishes walls with the iron bars fitted to it.

Utpāṭīma is interpreted as the *Syena-yantra* which uproots and tears up things.

And before the *Trisūla* and *Cakra*, which are known, there occurs the *Sataghñī*, the centicide, which is mentioned in all descriptions of warfare in old literature, but as to the exact nature of which there is difference of opinion. Bhaṭṭasvāmin takes it as a huge, cannon-like, cylindrical thing with wheels, placed on the parapet.

¹⁰ H. M. ELLIOT, *History of India*, Vol. VI, App., p. 477.

Bhaṭṭasvāmin quotes also a verse on yantras in general as of three kinds, *Vyādhita*, *Bhrāmīta* and *Bhārayukta*: the first acts by being pressed, the second by rotation and the third by its sheer weight.

व्याधितं भ्रामितं चैव भारयुक्तं च कारयेत् ।

पीडनाद् भ्रमणाद् भाराद् त्रिधा यन्त्रं प्रवर्तते ॥

The Jain Sūtras, which may go back in their nucleus to Mauryan times and which attained their present form in the 6th century A.D., know these yantras. The *Bhagavatī Sūtra* gives a list of eight finalities one of which is the last fight with huge stones thrown as missiles.¹¹ The same Sūtra describes the war between Kūṇiya and Chedaga where we have the expressions *Mahāsilā-kaṇṭaka-Sangrāma* and *Ratha-musala-Sangrāma*; the correct construction of the first name is "a battle in which one is beset by the stone complex," for the text itself elaborates that such a heavy stone-shower has been in operation that even if a blade of grass or a piece of wood, a leaf or a pebble struck one, one got the fright of a stone. The *Ratha-musala* is described by the text as a mechanical chariot which ran about without horses or driver and worked carnage in the enemy lines.

Hoernle has the following note on these two, *Mahāsilā* and *Ratha-musala*, which are clearly war-machines: "...the *Mahāsilākaṇṭaka* must have been some engine of war of the nature of a catapult which threw big stones. It created such a panic among the enemy that all fled...the *Ratha-Musala* would seem to have been a sort of 'scythed chariot'¹² such as the ancient Persians used to employ in war, but apparently furnished with clubs instead of scythes. It would also seem to have been provided with some kind of self-acting machinery to propel it, as it is described as having moved without horses or driver; though, possibly, as in similar contrivances in the middle ages, it was moved by a person concealed inside who turned the wheels."¹³

The above marks off one period in the history of these yantras. One of the questions that naturally agitate one's mind at this stage is that of firearms in ancient India. The throwing of arrows with fire or with combustibles on them is no doubt very old and forms one of the things prohibited by Maṇu in righteous warfare. Some of the other arms and machines mentioned by Kauṭilya do appear to be firearms.

¹¹ See A. F. R. HOERNLE'S Translation of the *Uvasakadasao*. (*Bibliotheca Indica*, 1888, App. I, p. 7.)

¹² Cf. Roger Bacon (latter part of the 13th century A.D.) in his *Epistola de secretis operibus*: "Also cars can be made so that without animals they will move with unbelievable rapidity; such we opine were the scythe-bearing chariots with which men of old fought." (THORNDIKE, *op. cit.*, Vol. II, p. 654.)

¹³ HOERNLE, *op. cit.*, App. III, pp. 59-60.

Writers like Elliot¹⁴ and Oppert¹⁵ have canvassed the subject at sufficient length in favour not only of the prevalence of firearms in ancient India but also of India being the original home of gunpowder, the fire meant being not merely naphtha.¹⁶

Without being able to subscribe to Oppert's early date for the *Sukranīti*¹⁷ or the *Nitiprakāśikā* of Vaiśampāyana,¹⁸ one feels that there is much to be said in favour of the findings on the antiquity of firearms in ancient India. Two data cited by Oppert and Elliot have some significance in relation not only to the use of yantras in battle in the ancient times but also to the question of the yantras and the *Yavanas*. As we shall see, Bāṇa, Daṇḍin and Budhasvāmin associate yantras in general and the aerial vehicle in particular with *Yavanas*. The *Yavanas* may mean Greeks or Arabs and, at the time when these are mentioned, the 7th-10th centuries, both meanings are possible.¹⁹

Now we have the following corroborative evidence on the use of yantras by these peoples:

Towards the end of the 7th century the architect Kallinikos of Heliopolis, when Constantinople was besieged by Arabs in 668, manufactured big tubes made of iron or of other metals formed like big beasts with gaping jaws, out of which were thrown iron, stones and combustibles. In consequence of the havoc caused by these projectiles the siege of the city was raised. The Greeks kept, it is said, the composition for four centuries when it was betrayed to the Saracens, who availed themselves of it during the crusades at Jerusalem and also at Damietta. (Oppert p. 47)

Elliot says that²⁰ "when the Muhammadan connection with India first commenced, we find, according to the ancient and authentic historians, that the powerful engine called *Mañjanik* was brought into use as a propelling machine. It was a favourite implement with the Arabs" and was probably received from the Persians. Muhammad Qasin used it in the capture of the port of Daibal (711-712 A.D.). It required 500 men to operate it and it worked havoc. According to the authority Ibn Kotaibah, this machine was used by Jazynah, the second King of Hyrah, as early as c. 200 A.D.

¹⁴ ELLIOT, *op. cit.*, Vol. VI, App., pp. 455-482.

¹⁵ G. OPPERT, *On the Weapons, Army Organisation and Political Maxims of the Ancient Hindus with special reference to Gunpowder and Firearms*. 1880. See also *I. H. Q.*, Vols. VII and VIII.

¹⁶ On the early use of gunpowder in the East see also M. AKRAM MAKHDOOMEE, "Mechanical Artillery in Medieval India." (*Journal of Indian History*, Vol. XV, p. 185)

¹⁷ Ed. OPPERT. (Madras, 1882)

¹⁸ Ed. OPPERT. (Madras, 1882)

¹⁹ On *Yavanas*, even in more ancient references in Sanskrit, being Persians or Iranians, see SPOONER, *op. cit.*, pp. 433-34.

²⁰ ELLIOT, *op. cit.*, p. 461 ff.

Elliot also collected the following data pertaining to certain mechanical objects used in warfare in India: the *Majmalu-t-Tawarikh* says that the Brahmans advised²¹ their King to employ on the battle field an elephant of clay which, as soon as the enemies were sufficiently near, would explode and blow them up; more than the mere explosion, the device for timing it is to be noted here. Firdusi refers to a similar explosive Iron Horse which Alexander was advised to employ, and blacksmiths and artisans constructed 1,000 of these for Alexander. In a Chinese account of India, reference is made to the use in Indian warfare of flying ladders, wooden oxen and rolling horses. One of Muhammad Qasim's successors used a "battering ram with horns of great power and demolished with it the walls of the city."

The Yavanas referred to being Greeks is rendered probable by two circumstances; one the antiquity of the yantras, particularly of war, in India, going through Kautilya to the epic literature itself, and the other, the evidence available on the Greeks and automata; there are numerous correspondences that can be fully appreciated only after we deal with the material found in Sômadeva and Bhoja; for which reason I have reserved them to the end.

The references to machines in classical Sanskrit literature that we may now examine start with Bâna's *Harshacarita*, the biography of his patron, King Harshavardhana of Kanauj (606-647 A.D.). When Harsha had decided to go against the King of the Gaudas—who had been responsible for the death of his sister's husband and of his own brother—Skandagupta, a loyal friend and courtier of Harsha, expatiates on the need for caution and exhorts the king to give up his wonted habit of trusting everybody. Illustrating the calamities that befell kings in the past from unsuspected quarters, Skandagupta narrates a series of anecdotes of kings, attached to certain recreations or habits, being taken unawares by scheming enemies and done away with or brought into difficulties. One of the incidents mentioned here records that one Candipati was always curious about miraculous things and that a Yavana who had been brought under his control, manufactured a machine-vehicle that could fly, and carried away the King:—

आश्चर्यकृतहली च चरडीपतिः दराडोपनतयवननिर्मितेन
नभस्स्थलययायिना यन्त्रयानेन अनीयत कापि ।

The mention of a Yavana as the maker of the aerial vehicle must be noted.

Daṇḍin, who came soon after Bâna, and wrote from Kāñcī in South India, has much more and more varied information to give in the autobiography attached to the opening portion of his prose work, the *Avantisundarī*; this

²¹ *Ibid.*, pp. 475, 476, 463. See also MAKHDOME, *op. cit.*, pp. 189-195.

forms the full text of the truncated *Daśakumāracarita*, and the introductory portions referred to are still in manuscript.²² In one of the introductory verses praising earlier poets, Daṇḍin introduces yantras; praising the author of the *Mahābhārata*, he says that, but for the knowledge that Vyāsa infused in us, we would merely be human machines:—

मर्त्ययन्त्रेषु माहात्म्यं महाभारतविद्यया ।
अर्पयामास तत्पूर्वं यस्तस्मै मुनये नमः ॥

In Daṇḍin's own life-story, a gifted architect Lalitālaya, son of another eminent architect Māndhātā, is introduced and the achievements of these two, which form the subject of the amazed talk of the people, are set forth. It is said here that the father excelled even the Yavanas, from which we have to deduce that Māndhātā and his son Lalitālaya were natives of the soil. Once the father, anxious lest his young son might be hungry, rushed to him in an aerial car, evidently from a distance where he had been at work; which shows how casually the architect took his personal equipment of an aerial vehicle.

The son, who is the actual character figuring in the narrative, and is said to excel his father, is credited with the following achievements, the description of which forms a brief treatise on yantras. Lalitālaya created mechanical men and arranged for the exhibition of a mock-duel between them; he created an artificial cloud and brought down heavy showers; with yantras, he exhibited magic; he devised a machine for war from which shafts as stout as pestles were discharged by him on the heads of elephants.

दृष्टेऽपि तस्मिन् विस्मयस्पृशो जनस्य "अयं किल यन्त्रपुरुषैः द्वन्द्वैः युद्धमहीनमादर्शितवान् ।
अनेन किल अलीकजलधरधारजलजालदन्तुरितमन्तरिक्षं कृतम् । एष किल यन्त्रमयमिन्द्रजालकं
कृतवान् । एष किल संख्येषु असंख्यानानां युगपदेव भिनत्ति शत्रुहस्तिनां मस्तकस्थलानि मुसलमात्राभि-
रिषुभिः । अमुना किल द्रमिडभाषया शूद्रकचरितमुपनिबद्धम् । अस्य किल पित्रा यवनानप्यतिशयानेन
क्षुधितोऽयमिति यन्त्रेणाभिधावितम् । अयं ततोऽप्यधिकः किल " इत्येवमासन् विकसितकुतूहलाः प्रलापाः ।

Lalitālaya is said to be master of all kinds of yantras; the varieties mentioned in this connection are six, *Sihita*, *Cara*, *Dhārā*, *Dvīpa*, *Jvara* and *Vyāmisra*. Other texts speak of the classes of yantras as two and five and give the classifications somewhat differently. The *Sihita* or *Sihira* and *Cara*—stationary and mobile—is a classification going back to Kautilya. *Dhārā* is plainly water-works; the manuscript gives the next as *Dvīpa*, which had been wrongly construed also by some; *Dvīpa*, I think, is an error for *Dvīpa*, meaning elephant, and refers either to animal-shaped yantras or to special machines,

²² The relevant portions are cited here from the transcript of it with the Curator of the Travancore University Oriental MSS. Library.

such as we have already noted, employed against elephants in battle; *Jvara*, if it means heat, may refer to machines involving the employment of fire. *Vyāmiśra* is a yantra partaking of the character of all these.

कल्पवृक्षक्रियाविस्मापितदुर्जयस्य मान्धातुनाम्नः स्थपतेः प्रशस्तवास्तुशास्त्रार्थसारसामस्त्य-
संहारोन्मीलितप्रयोगतन्त्र....वास्तुविस्तारकुशलः परणवतिप्रासादविधिविशारदो यानासनशयनादि-
विकल्पनापटुः स्थित-चर-धार(रा)-द्वीप (द्विप)-ज्वर-व्यामिश्रसंज्ञानां षड्विधानां यन्त्राणां अद्वितीयप्रयोक्ता
षड्त्रिंशदाचार्यगुरौः अलङ्कृतः ललितालयनामा समस्तसूत्रग्रही वर्धकी तत्कल्पप्रतीच्यः क्षत्रियैश्च
संस्कृतः (संस्कृतः) स्थपतिरभ्येत्य विरचिताञ्जलिराद्रदृष्टिर्निर्दिष्टायां भूमावुपाविशत् ।

अवसिता एव सर्वे नित्यप्रमादशैथिल्याभ्यां शिल्पातिशयाः, यतो अद्य त्वेवं प्रयोगलेशोऽपि
विस्मयाय लोकस्य । युष्मादृशां तु ब्रह्मेन्द्रपराशरप्रभृतिप्रणीतशास्त्रहृदयवेदिनां कियदिवैतच्चैपुणम् ।

The machines referred to here are confirmed on either side by Kauṭilya in his *Arthaśāstra* and Bhoja in the *Samarāṅgaṇasūtradhāra*. The mechanical fighters are included in Bhoja; the artificial rain occurs in Kauṭilya in the yantra called Parjanya, and the machine intended to smite the elephants' heads may be related to the Hasti-yantra advocated by Kauṭilya for use against an elephant corps. From a passage that follows it would appear that these yantras are dealt with in treatises associated with the authors Brahmā, Indrā and Parāśara, and that their vogue had become so reduced by long neglect that even humble efforts in the line excited people's wonder.

We now proceed to cite some texts on the existence and popularity of a different category of yantras. Till now we have been dealing with yantras having mainly the background of war. The yantras we shall now deal with are accessories of pleasure and entertainment, and more properly come under household fittings and architectural engineering. Some of them are for the reduction of human labour, some for sport and merriment,—toys and gadgets of miscellaneous kinds for entertainment.

We may begin with Somadeva Sūri, an encyclopædic Jain writer, and his long religious poem, the *Yaśastilaka Campū*,²³ written in South India in 949 A.D. In the first part of the work, Somadeva describes the hero resorting to the cool *yantra-dhārā-griha* to spend the hot hours of the summer days. This park, fitted with mechanical fountains, is appropriately called by the commentator *Kṛitrīma-megha-mandira*, the artificial cloud-pavilion. It is erected in the dense garden in an area provided with many canals. There is the stream for water sports in the midst of which is a sandbank raised like a pavilion, provided with a water-bed, *Salila-tūlikā*; nearby are numerous vessels containing fragrant

²³ *Kavyamala* 70, in two parts. See Part I, pp. 522-32. See also the present writer's "Gleanings from Somadeva Sūri's *Yaśastilaka Campū*," *Journal of the Ganganatha Jha Research Institute*, Vol. I, Nos. iii-iv (May-August 1944) pp. 378-9, 467.

water; at one end here is an *yantra-jala-dhārā*, a contrivance producing an artificial waterfall; the water is taken through and thrown out of the mouths of figures of elephants, tigers, lions, snakes, etc.

Other artificial works here are figures of celestial trees, *Kalpavrikshas*,²⁴ with celestial damsels seated on them along with their lovers and figures of cloud-damsels (*payodhara-purandhri* or *Meghapūttalikā*) giving shower-baths from their bosoms, figures of monkeys spouting water, statuettes of water-damsels (*jaladevatās*); there are wind-damsels (*pavana-kanyakās*), wafting breezes with fly-whisks; and figures of ladies, scattering cool sandal-water all around. Somadeva Sūri says of such a figure that if her hands were touched, she would emit sprays through her nails; if her face, through the eyes and so on, a description which, as we shall see presently from its corroboration in every detail in Bhoja's treatise,²⁵ pertained clearly to fact and not to mere imaginative fiction.

That mechanical fountains were constructed as a necessary adjunct to all palaces is seen even in the casual descriptions in the dramas, the *Mālavikāgnimitra* (II. 12) and the *Nāgānanda* (III. 7) for example, describing *jala-yantras*.²⁶ The mechanical breeze-lady in the *yantradhārā-griha* in the park has her companion within the bedchamber where Somadeva Sūri describes how near the bed was a *yantra-putrikā* plying a fan for the King's relief.

उपान्तयन्त्रपुत्रिकोत्क्षिप्यमाणव्यजनपवनापनीयमानसुरतश्रमः ।

Many others of this class we shall be meeting in Bhoja.

Bypassing chronology a little, I shall now take up three available Sanskrit versions of the *Brihatkathā*. The story thesaurus called *Brihatkathā* is on a par with the two epics, and can very well be called the great epic of popular life. The version of Budhasvāmin is the earliest, belonging probably to the 9th-10th centuries, and coming from and based on a non-Kashmirian area and source. Budhasvāmin has important information on aerial vehicles, *Ākāśa-yantras*, as he

²⁴ The "Kalpavriksha" is referred to by Bhoja also, and Dandin's references to *Kalpavriksha-Kriya* as a work in which Mandhata excelled must be to this.

²⁵ On the close parallels on this subject between Somadeva and Bhoja, see Note on the same by the present writer in the *Journal of the University of Gauhati*, Vol. III.

²⁶ (a) विन्दुक्षेपान् पिपासुः परिसरति शिखी भ्रान्तिमद्वारियन्त्रम्

(b) यन्त्रोन्मुक्तश्च वेगाच्चलति विटपिनां पूरयन्नालवालान्

आपातोत्पीडहेलाहतकुसुमरजःपिञ्जरोऽयं जलौघः ।

(c) *Prabodhacandrodaya*, II. 15 and IV. 27: मुच्यन्तां यन्त्रमार्गाः प्रचरतु परितो वारिधारा गृहेषु, which refers to the water-works being set in action and अग्नी-धार-यन्त्रस्त्वक्षितजलभङ्गारमुखराः ।

expressly calls them; it is also to be noted that he explicitly mentions the Yavanas as the knowers of these Ākāśa-yantras, and the geographical area where he locates the architect and his exploits is also the part of the country where the foreign tribes had settled. The names of the architects too bear a strange complexion, suggesting their foreign origin.²⁷

The context where the description of the "yantra" occurs is the longing of the pregnant Vāsavadattā; in the Kashmirian version of Somadeva there is only a line saying that her *dohada* (longing) was fulfilled by manifold contrivances, yantras, etc., arranged by the Minister Yaugandharāyaṇa. But in Bṛhadhasvāmin's version²⁸ the context contains an elaborate digression devoted to the yantras. Vāsavadattā yearned to see the whole world from above in an aerial vehicle (Śloka 190); Rumaṇvān, the commander-in-chief,²⁹ at once ordered carpenters to manufacture a flying yantra (Śloka 196). The carpenters say that they know only four kinds of yantras, made respectively with water, stone, mud and twigs; that it is the Yavanas who know the Ākāśa-yantras, and that they, for their part, have not even laid eyes on them.

आकाशयन्त्राणि पुनर्यवनाः किल जानते ।

अस्माकं तु न यातानि गोचरं चक्षुषामपि ॥

Thereupon a Brahman told Rumaṇvān a story to illustrate how in the matter of the aerial vehicle, architects made a secret of their lore and uttered the falsehood that they knew it not.

With Mahāsena, King of Ujjain and father of Vāsavadattā, was an architect named Pukkasaka who once went out to Saurāshtra along with the King's camp. There he came across a young architect, Viśvila by name, who was verily the equal of Viśvakarman. To Viśvila's father, called Maya, Pukkasaka proposed that he desired to give his daughter Ratnāvalī in marriage to his son. The proposal was agreed to and Pukkasaka was waiting for the arrival of his son-in-law. Once, after attending to his work, Pukkasaka returned rather late and to his surprise found none in his house eager to attend to his bath and his dinner.

On enquiry, he heard from his wife that a visitor had upset their home; the visitor had come over with some rice and asked that it be cooked for him;

²⁷ It may be mentioned here that the association of skilled works with Yavanas had become so well known that we find it mentioned in Tamil literature also. In the fragmentary Tamil version of the *Bṛhatkatha*, by Konguvel, Yavana carpenters are included among the workmen of many types responsible for a chariot of high workmanship used by Udayana (I. 58.40); and in the Buddhist epic *Manimekhalai*, in an almost similar list of workmen mentioned as responsible for a garden house of great architectural charm, Yavana carpenters are again found (XIX. 108).

²⁸ Ed. F. Lacote (Paris, 1908) Canto V, p. 64 ff.

²⁹ The substitution here of the military head shows the natural connection that these yantras bore to the army.

they in the house had been burning loads of fuel and yet the rice would not even moisten. Pukkasaka now understood that his son-in-law had arrived and desired to see the youth. Viśvila issued out of the workshop and when the puzzled Pukkasaka asked him what that so-called rice was, Viśvila revealed that they were fake, fine rice-like chisellings from the white wood of the Karaghāṭa tree. The marriage of Viśvila and Ratnāvalī was then celebrated. After a time, Viśvila learnt from his brothers-in-law their anxiety about feeding in their house one more family member in the form of the son-in-law; Viśvila at once repaired to the forest, cut down certain kinds of wood and manufactured out of them yāvana-machines,

यन्त्राणि घटयामास यावनान्यथ विश्वितः ।

(Śloka 224)

as also manifold household utensils conducive to health and longevity, according to the principles laid down in *Vrikshāyurveda* (225); he sold these for thousands of pieces of money and presented the gains to his father-in-law.

Once Pukkasaka sadly told his family of his impending departure for Benaras whither King Mahāsena had ordered him to go to build a temple for his friend King Brahmadatta of Benaras. Viśvila asked leave to deputize for his father-in-law and, with the King's permission and accompanied by a retinue, he departed for Benaras. At the end of every day's journey, however, Viśvila would vanish somewhere and slip back inconspicuously into the camp. At his home, Ratnāvalī shortly became pregnant, to the surprise and agony of her parents. That news reached the King who, putting two and two together, explained that every night, Viśvila, according to the report of the men of his retinue, would mount a machine-cock, *Yantra-kukkūṭa*, fly away somewhere and, stealthily and with shrouded face slip back into his bed in the small hours of the morning. Once he had been forced to return late in the morning and, confessing to his friends about his nocturnal visits to his wife by an aerial vehicle, he had begged them not to inform any, architects or laymen, of the secret of his aerial vehicle, which in fact could not be understood by non-Yavanas; if that knowledge became public, the Ākāśa-yantra would become a cheap affair like a cot.

आकाशयन्त्रविज्ञानं दुर्विज्ञानमयावनेः ।

खट्वाघटनविज्ञानमिवेदं प्रचुरीभवेत् ।

लोकेन परिभूयेत क्षणरागा हि मानुषाः ।

(Ślokas 250-2)

That explained how Ratnāvalī came to bear a child. Soon the temple at Benaras was finished and Viśvila returned.

King Mahāsena now pressed Pukkasaka for knowledge of the "Ākāśa-yantra." Pukkasaka replied that he had not taught Viśvīla; he, in fact, did not know it, the Yavanas being the custodians of that knowledge:

तस्मै तु कथितं प्रीतैः शिल्पिभिर्यावनैरिति ।

(Śloka 261)

The King would not believe his words and pressed him, whereupon Pukkasaka pressed Viśvīla. Viśvīla pretended to reveal the secret, but that night he woke up his wife and gave her an ultimatum; by pressing him for knowledge of the flying-machine, her father was virtually driving him to his own home, that she had to choose between father and husband, and that, so far as he was concerned, he would give her up rather than the secret. She took little time to decide and in a moment they were off on the machine-cock:

यानं कुक्कुटसंस्थानमास्थाय सह भार्यया ।

रात्रावाकाशमुत्पत्य स्वस्थानं विश्वितो ययौ ॥

Having told the story, the Brahman told the commander-in-chief Rumaṇvān that architects made such secrets of their knowledge, that all of them might well be bound and beaten till they agreed to make the aerial car. As Rumaṇvān was putting that advice into action, there came a fresh architect who offered to manufacture an aerial car.

The new *Silpin* asked Rumaṇvān to collect the materials. When these were assembled and the work was to start, the old *Silpins* suggested to the new one that he ascertain from Rumaṇvān the seating capacity that was required. The mention of this deserves to be noted, as also the further observation that there had been cases in the past in which aerial cars had been made without regard to seating capacity and they had come to ruin, with the result that their makers had been cruelly dealt with by the Kings:—

आरोहकपरीणाहं सेनानीरनुयुज्यताम् ।

अज्ञातवाह्यसंख्याभिः बहवः शिल्पिनो वृषैः ।

विपन्नयन्त्रैः श्रूयन्ते मथिताः कुपितैरिति ॥

(Ślokas 276-7)

The new *Silpin* replied that the yantra that he was going to make was of a superior type quite different from the productions of the stupid architects to whom they referred, and that the seating capacity of his vehicle was not limited. He made accordingly an aerial car of the shape of Garuḍa. Vāsavadattā and Udayana mounted it with their retinue, roamed about, called on Padmāvati's brother in Magadhā on the east and on Vāsavadattā's own parents at Ujjain on the west and returned to Kauśāmbī.

This fulfilment of the Queen's *dohada* during her pregnancy, for an aerial flight, has an echo in Jain *Kāvya* literature also; in Vādībhāsimha's *Gadya-cintāmaṇi*³⁰ and *Kṣhatracūdāmaṇi*³¹, carpenters make a peacock-like aerial car (*Mayūra-yantra*) for the pleasure flight of Queen Vijayā.

On smaller mechanical objects also we have some information in the *Slokaśaṅgraha* of Budhasvāmin (Chapter XIX, p. 287). At Campā, when Naravāhanadatta was staying with Gandharvadattā, they heard the story of the origin of a local water festival. An old King of Campā had a Queen whose *dohada* during pregnancy expressed itself as a desire to move about in waters filled with all sorts of aquatic beings. For her sake the King dammed a river, widened it into a big lake and fitted it with wooden replicas (*Dāru-yantras*) of crocodiles, fishes, etc., which moved freely in the water, and there let her sport in a vessel shaped like an aerial vehicle.

तत्र नक्रादिसंस्थानदाहयन्त्रनियन्त्रिते ।

विमानाकारपोतस्थौ तौ राजानौ विचेरतुः ॥

Of the two Kashmirian versions of the *Brihatkathā*, Kshemendra's is very brief, and Somadeva's long enough for us to glean much information about yantras. These two works may be noticed together. We have here material bearing on three classes of yantras, dolls and entertainment pieces, mechanical men and women, and aerial vehicles.

In the course of the Madanamañcukā story in VI. 3, Somadeva narrates in his *Kathāsaritsāgara* the episode of Somaprabhā, the daughter of Maya, who takes a fancy to Madanamañcukā and becomes her great friend; Somaprabhā and Svayamprebhā, of *Rāmāyaṇa* and *Pañcāpsaras* fame, were two daughters of the Asura architect Maya. One morning Somaprabhā calls on Madanamañcukā with a wonder-box full of various kinds of mechanical dolls. Maya himself had taught Somaprabhā how to make these yantras, mechanical wooden toys.

Then follows a description of four of these toy-yantras: By striking at a pin, one makes a yantra jump up in the air and it comes down with a garland; another similarly comes back with a cup of water; a third dances; and the fourth sits up and gossips. After entertaining Madanamañcukā with these, Somaprabhā leaves the box in the former's care and departs. Next day, when she calls again, Madanamañcukā introduces her to her own parents. The two then go to the royal park where one of the toys brings forth a Buddha image and materials for worship. Hearing of this, the parents rush to see the wonder, and on the King asking her about the yantras and how they go into action,

³⁰ and ³¹ Eds. of T. S. KUPPUSWAMI SASTRI (Tanjore), I, pp. 10-11, and Canto I.

Somaprabhā gives a short account of the yantras that her father had devised; the treatment here has some parallels with that in Bhoja's work.

Somaprabhā says that, just as the universe is made up of five elements, yantras are also based on the five elements of earth, water, fire, air and ether. The yantra based on earth-materials (*prithvī-pradhāna*) undertakes activities like shutting doors; a *water-based yantra* will be as lively as a living organism; a *fire-yantra* emits flames; an *air-yantra* moves to and fro; and the element of ether serves to convey the sound generated by these yantras. Somaprabhā adds that there is a *super-yantra* called *Cakra-yantra* with miraculous powers which her father did not teach her, but in the description of this there is an obvious mix-up of mythology. Then, with the parents' permission, Somaprabhā takes Madanamañcukā in an aerial car (49) to her own father's place, where her sister Svayamprabhā is living, and returns to Takshaśilā. Kshemendra's account of this episode is brief, comprising about a dozen verses in his *Brihatkathāmañjarī* (VII. 195-207).

The other story in which yantras figure mainly is in the *Ratnaprabhā-lambaka*, VII. 9, the story of Karpūrikā in the city of Karpūrasambhava, of whom Naravāhanadatta has a dream. The Prince starts out in search of her, in the company of Gomukha. *En route*, they come to a Hemapura, where, as Naravāhanadatta is going along the bazaar street, he comes across everything pertaining to a city, shops, things, servants, men and women, but their speechless movements and activities reveal to him the wondrous fact of their all being robots (10, 11). He then makes his way to the palace where he finds the only sentient being sitting on a throne like a king, and, like the soul presiding over the body and senses, manipulating the mechanical city and being served on all sides by his mechanical servants. On being asked by Naravāhanadatta, the mystery man of this machine city recounts his story:

He, Rājyadhara by name, and his elder brother Prāṇadhara, were originally residents of Kāñchīpura where King Bāhubala (Mahābala in Kshemendra) was ruling. Both of them were architects and adepts in the manufacture of magic yantras made of wood, etc., and devised originally by Maya. It may be noted in passing that, according to Daṇḍin, Kāñchī had some architects who were adepts in the making of yantras. The elder brother sought the company of courtezans and squandered his as well as his younger brother's property. Reaching the end of his material resources the elder brother thought of theft and harnessed his skill in yantras for that purpose. He devised a pair of wooden swans which could move along a rope-contrivance manipulated from one end. The other end of the rope was tied to the window of the King's treasury into which, night after night, these swans were sent; their beaks,

which were put into action, removed the lids of jewel boxes and picked up some jewels and then the swans were again moved back to their original place. This mysterious theft was going on, and the King ordered an all-night vigil to catch the culprits. The swans were seen doing this dexterous job and were detached from the rope, which suddenly sagged; the fastening nail became loose and Prāṇadhara understood at once that the theft had been found out. He asked his brother to accompany him to a far-off place to escape being caught as thieves early in the morning. Prāṇadhara said that he had with him an aerial vehicle that could in a single sweep rocket across 800 *yojanas* and got into it immediately, with his family. As the seating capacity of that yantra had been reached by the crowd that entered it, Rājyadhara left in his vehicle, a *vāta-yantra-vimāna*, as it is here styled, which he himself had made; that machine took him at one jerk over 200 *yojanas*, and with a second propelling, over another 200 *yojanas*.

That brought the younger brother, the narrator, to the city of Hemapura. When he reached it, it was an abandoned place; he thought of peopling it with the help of his mechanical skill and created a yantra-population. Next day, he learnt from Naravāhanadatta the search that the latter was on, and helped him with an aircraft which took him to the city of Karpūrasambhava. There the Prince found the heroine of his dream, Karpūrikā, and married her. When he desired to return home with his new bride, his father-in-law revealed that he too had a visitor-architect in his city who could provide him with an aircraft. It happened that the visitor-architect was no other than Prāṇadhara, the elder brother of Kāñchī. The vehicle that Prāṇadhara gave him was a veritable flying fortress, as it could lightly bear a thousand passengers (228), and in that they returned home, touching Rājyadhara's city *en route*.

In Kshemendra's brief narration of this story (XIV. 459-508), the thieving swans are mentioned as many, the elder's aircraft is called a *Yantracakra*, and the younger's is said to possess double the speed of the elder's.

There are also two other contexts in the *Kathāsaritsāgara* where the aerial yantra figures (the story of Pushkarāksha and Vināyavatī and the story of Somaprabhā and the three suitors).

It now remains for me to deal with two works of Bhoja, one a poetic composition and the other a technical treatise. The former, which is yet unpublished, is the prose work of fiction, *Śringāramañjarī*.³² In it, Bhoja himself is the hero and, as it is not proper for a noble soul to indulge in self-glorification, the

³² Available in an incomplete Ms. in the Jesalmere Bhandars, being worked upon by Srimati Kālpalata Munshi; it is through the courtesy of Muni Jinavijayaji and Srimati K. Munshi that I was able to examine this work.

device is adopted of making a mechanical figure (*yantra-putrikā*), discharged function. Confirming almost all the details set forth on the one side by Soma-deva in his *Campū* and on the other by Bhoja himself in his book on architecture, this work gives an elaborate description of a *yantra-dhārā-griha*, a fountain pavilion with manifold mechanical works: there are figures in constant action; there is a *jalayantra-putrikā* which scatters a fine spray; *dhārās* which fall like slender lotus-stalks, and in a curve like a bow; mechanical drum-players filling the place with their rhythms; an artificial lotus pond; toy bees which keep humming; *yantra-vriksha* or trees, with monkey figures; a pond filled with replicas of cranes bending over and getting deceived by fishes which come near and move on; artificial tortoises diving and coming up every now and then; and yantra-orchestras.³³

The *Samarāṅgaṇasūtradhāra* ascribed to Bhoja is, in many ways, a rare treatise in Sanskrit literature; besides the *Arthaśāstra*, it is the only theoretical text that has substantial information on our subject; its value, however, is greater than that of the *Arthaśāstra*, as Bhoja goes into the details of the construction of these yantras and explains at the beginning the principles underlying yantras.

Chapter 31 of the *Samarāṅgaṇasūtradhāra* is called *Yantravidhāna* and its 224 verses are wholly devoted to a description of various mechanical constructions. Bhoja opens with the definition of yantra, that it is so called because it controls and directs, according to a plan, the motions of things that act each according to its own nature. As we have seen and as Bhoja explains, it is from the principle of control, *yam*, that the name yantra is derived (3, 4).

The next topic Bhoja deals with is *Bija*. *Bija* means a constituent element. The constituent elements of a yantra are four: Earth, Water, Fire and Air, Ether being the basis and medium of action, *Āśraya* (5).

Bhoja then discusses whether *Sūta* or mercury, which is an indispensable ingredient, is to be held as one of the *Bijas* along with Earth, Water, etc. Some earlier writers had counted it separately as a *Bija*. Bhoja says that mercury is essentially *Pārthiva*, i. e., to be brought under Earth, though one might find it in the liquid state and also possessing a property causing motion, like wind. (6-8).

The machines are then divided into two classes, *Svayam-vāhaka*, automatic and *Sakrit-prerya*, requiring occasional propelling; most machines combine these two features (13). Another classification is: the concealed, *Antarita* or *Alakshya*, i. e., the principle of its action and its motor-mechanism are hidden

³³ All this music too was produced by the water-works. Cf. Vitruvius and his black-birds singing by means of water-works. (THORNDIKE, *op. cit.*, Vol. I, p. 188).

from public view; the *Vāhya*, or the machine to be carried by another; and the third, which is really obscure, but may be interpreted as the distant or proximate, meaning thereby the place from which the machine acts (10-11). Some move many persons and things while others require many persons to move them (49). That machine is best whose principle of action is concealed,³⁴ which achieves manifold purposes and which excites wonder (12).

After a lavish encomium on the comfort and advantages to be enjoyed through the machines, Bhoja proceeds to describe the constituent elements called *Bijas* of each variety, the *Pārthiva*, *Taijasa*, etc.; while all the elements may be used for a single yantra, it is to be named after the dominant constituent (21-25, 42). Then are mentioned the materials: metals—tin, iron, copper and silver—and wood, hide and textiles; the parts and the principles: the wheels and the rotation; the suspenders and the hangings; the rods, the shafts and the caps; the tools; and the work: measuring, cutting etc.—all these are also to be included under the *Bijas* of a *Pārthiva-yantra* (25-27). The application of fire-*bijas* on earth-machines comprises heating and boiling; of water, mixing and dissolving, pouring of and filling with water, and providing a belt of water. Height, size, closeness and motion towards a higher plane are spatial features in *Pārthiva-yantras*. The element of air is to be applied through bellows, fans, flaps, etc. (28-32). Similarly in machines which are mainly *jala-yantras* the use of timber, hide and metal forms the *Pārthiva* element and so on. (33-41). As, however, machines have to take some shape and possess a body, the *Pārthiva* is an important constituent (43-44).

The merits of a good machine, *yantra-guṇās*, are as follows:—

1. Proper, proportionate utilization of the elements constituting it.
2. Well-knit construction.
3. Fineness of appearance.
4. Inscrutability.
5. Functional efficiency.
6. Lightness.
7. Freedom from noise where it is not part of the scheme.
8. A loud noise when noise is intended as an end.
9. Freedom from looseness.
10. Freedom from stiffness.
11. Smooth and unhampered motion.
12. Production of the intended effects (in cases where the ware is of the category of curios).

³⁴ Cf. "*Alakshya-mādhyam*" in Bhoja's description of the wonderful machine called the Universe in the opening verse of this chapter.

13. The securing of the rhythmic quality in motion (particularly in entertainment-wares).
14. Going into action when required.
15. Resumption of the still state when not required (chiefly in cases of the pieces for pastime).
16. Freedom from an uncouth appearance.
17. Verisimilitude (in the case of bodies intended to represent birds, animals etc.).
18. Firmness.
19. Softness.
20. Durability. (45-49).

Now to the *Karman* or action of these: Machines are characterized not only by an action peculiar to each but also by the particular times when they are to operate. The speciality of some is sound; of some, height, form or touch; and so on. Action is across, upward, downward, backward, forward, on either side, speeding and crawling. Another factor is the time taken for the action. In sound, the factors are variety, the quality of pleasing or the capacity to terrify. In contrivances for pure entertainment, music, dance, drama and imitation of different things and beings are the main factors, each, like music and dance, having its sub-varieties. In motion, going up and coming down. For the reproduction of whole themes in machinery, Bhoja instances the fight between the Devas and the Asuras, the churning of the ocean, Nrisimha killing Hiranyakasipu, races, elephant-fights, a mock-army, etc. (50-62).³⁵

Among fittings for utility, beauty and sport, various types of shower-fountains (*dhāra-grihas*), swings, pleasure-chambers, mechanical carriers and servants, balls and magic (?) are mentioned. (63-64).

Bhoja now proceeds to describe some of the things that can be accomplished through yantras:

1. Five storeys could be arranged and the bed placed on the ground floor made to go up to each higher floor at the end of each watch of the night. (65).
2. Another pleasure-contrivance is the couch called *Kshirābdhisayana*, in which the serpent-like bed goes up and down by the soft action of air, like that of the serpent's breathing. (68-69).

As examples of miracles that could be worked through yantras, Bhoja mentions the production of fire in the midst of water and *vice versa*; effecting

³⁵ *The Life of Apollonius of Tyana* by Philostratus (c. 217 A.D.) has references to Brahmans and the employment of mechanically contrived figures for service and mechanical singing birds. (Thorndike, *op. cit.*, Vol. I, pp. 250-66, especially 252 and 266).

the complete disappearance of a thing present before one and the projection before one of the view of a thing not present before him (67-68). How these were done is not stated.

In Verses 66-67, a kind of chronometer is described; there is a circular device in which, in a broad open vessel, there are thirty, probably ivory figures, or tooth-like pieces lying flat all along the circumference; the whole thing is revolving; in the centre is the figure of a lady, who wakes up one figure or piece for every *Nādikā*.

Another chronometer-like object is described in Verses 70-71: there is a rider on a chariot, an elephant or any other animal; for a fixed time, say, a *Nādikā*, the rider on his mount goes round and at the end of the *Nādikā*, the chronometer strikes.

An astronomical model called *Gola* is then described (69-70), in which there are needles and the day and night movement of planets is shown.

Among mechanical contrivances given is a lamp into which, at set intervals, a mechanical figure goes on pouring oil. An additional feature of this is that the figure keeps on circumambulating to a definite musical rhythm (71-72).

Other entertaining yantras are speaking, singing and dancing birds, a dancing elephant, horse or monkey, water going up and descending, a mock-fight and others worked by the manipulation of air. (73-78).

Bhoja concludes this section with the observation that not only these, but many more similar contrivances could be invented; even movements impossible in actual life are possible in yantras. Regarding the actual process of making these, Bhoja says that, though it is not set forth, the constituent elements and basic principles have been mentioned, so that men of imagination could easily construct these. Silence on the actual mode of construction is said to be for preserving this important knowledge, for giving a material advantage to the architects, and for enhancing curiosity about these yantras. (79-81).

Another interesting statement that Bhoja makes is that some of the yantras described by him are those actually seen by him (*drishtāni*); more important is his information that follows, *viz.*, that he would now proceed to describe some more, handed down from earlier masters. (82-83):—

अप्रतश्च पुनर्द्वयः कथितं यत्पुरातनैः ।

After speaking again of the *Bijas* or constituent elements and the wonder and pleasure of these yantras, Bhoja refers to the *Sūtradhāras* or chief architects who do these; their qualifications are set forth as: (1) traditionally handed-down knowledge, (2) skill combined with schooling under masters, (3) practice and application, and (4) imagination. (85-87).

Five classes of yantras are then mentioned as constituting the five sections of the science of yantras, *yantra-sāstra-adhikāra* (86); the lines not being free from corruption, we are not able to make out these five classes of yantras to which reference is again made later; but movement, such as rotary; material, such as wood; purpose, such as the exhibition of dexterity and the satisfaction of curiosity; utilitarian value and pleasure, as in swings; and form, as in the round yantras (*cakra*) is about the best meaning that I can extract out of the context here.

A series of yantras now follows with some details of their manufacture :

1. A wooden bird in whose hollow body is placed a copper contrivance one inch long and one-quarter inch high, of slender cylindrical shape, in two well-joined halves allowing a hole at the centre along which air passes when the bird moves, creating a pleasing sound (89-90).

2. The next is actually noted as a bedroom accessory. In the hollow of the bird above mentioned is placed a small drum-like piece in halves and with an air-passage as in the previous yantra; the interior device is to be loosely hung and as the bird oscillates, a highly pleasing sound is created which reduces the anger of the ladies who are cross. (91-92).

Other bedroom accessories are various mechanical musical instruments which sound automatically on the principle of stopping and releasing air according to plan. (93-94).

The third class of yantra described is the aerial vehicle, to which we shall come last.

The fourth category comprises male and female figures designed for various kinds of automatic service. Each part of these figures is made and fitted separately, with holes and pins, so that thighs, eyes, neck, hand, wrist, forearm and fingers can act according to the need. The material used is mainly wood, but a leather cover is given to complete the impression of a human being. The movements are managed by the system of holes, pins and strings attached to rods controlling each limb. Looking into a mirror, playing a lute and stretching out the hand to touch, give pan, sprinkle water and make obeisance (101-4) are the acts done by these figures. It is one such that provides the mechanical fan in the *Yaśastilaka Campū*.

Similar robots are used for the palace guard; one such stands at the gate with a baton, sword, iron rod, spear or other weapon and prevents the entry of outsiders. This can quickly and quietly kill thieves who break into the palace at night. (106-7).

Bhoja closes this section with a reference to military equipment in forts, bows, *śataghnīs* and a weapon newly mentioned by Bhoja, the *Ushtra-grīva* (camel's neck), resembling probably the modern cranes. He also indicates here the classification into *Guptyartha* and *Kriḍārtha*, protective military yantras, and yantras for sport and entertainment. (108).

The sixth series now taken up by Bhoja in the *Kriḍārtha* class, is the fountain, *vāri-yantra*, described in some detail by Somadeva, and dealt with by Bhoja not only here, but also earlier under palace architecture. Movement in the *vāri-yantra* is fourfold: (a) a downward flow from an overhead tank for which a *Pāta-yantra* or waterfall-machine, is to be used; (b) *Śamanādikā* is for the release of water at a higher level from tanks placed at that level; (c) *Pāta-sama-ucchrāya* is a contrivance using bored columns for letting down water from a height, and then taking it up through columns placed aslant; and (d) the last, *Ucchrāya*, in which water from a well or in a canal on the ground is sent up by a device. (110-14).

An artificial object which was probably common in Bhoja's time is a wooden elephant which Bhoja describes twice; earlier he cited it as an example of various wonderful effects that could be achieved through yantras (72-3). It occurs here again under yantras based on the principle of sending water upward, *Ucchrāya* (115). This wooden-elephant drinks water placed in a vessel,³⁶ any amount of it, and neither the intake nor the water taken in is perceivable. On the *Samaucchrāya* principle of circulation of water on the same level is based the underground conduit which brings water to a tank from a distant source (116). Water conduits in general are described earlier also in Chapter 18 in connection with the city and residence.

In the class of up-and-down play of water, Bhoja expatiates upon the *Dhārāgriha*, shower-bower, in the garden; its popularity has already been noted, and Bhoja has already given a description of it in Chapter 18. Its great vogue can also be seen from its different types known by distinct names mentioned by Bhoja: (1) *Pravarshaṇa*, the shower, (2) *Praṇāla*, the pipe, (3) *Jalamagna*, the subaquatic, and (4) the *Nandyāvarta*, in a special design. These are constructed only in palaces for the King's pleasure. (117-18).

Regarding their construction Bhoja says: (1) They are to be in the proximity of big reservoirs; (2) They should occupy a site with good scenic possibilities; (3) Pipes have to be prepared to double and treble the height and other requirements of the fountains; the pipes should be able to carry water, be free from pores, and smooth inside (119-20). Naturally architectural

³⁶ Cf. in Vitruvius the figures that drink.

erections add to the excellence of the fountain-park and parts of the structure are themselves used for the different water-works.

Fine and fragrant timber, Devadāru, Sandal, Sal, are to be used for the woodwork, carved pillars, platforms, projections, windows, cornices, etc. The main items are female figures and models of birds, animals like monkeys, manifold forms with gaping mouths, semi-divine and half-human and half-animal forms, *Nāgas*, *Kinnaras* etc., dancing peacocks, *Kalpavrikshas*, creepers and bowers, cuckoos, bees and swans. In the centre of the flowing stream is to be fixed the main pipe, the exterior of it being made into any charming form according to one's liking. To the top of it is fitted and fastened strongly with *vajralepa*, cement, the devices for taking up water, scattering and throwing it in a variety of ways (133). The pond is to be filled, for effect, with yantras of animals and aquatic beings, e.g., sporting elephants which do even minute actions like closing their eyes when another throws water on the face (134); other specimens we saw in the description in the author's *Śrīngāramañjarī*. Female figures spraying water from eyes, nails, etc., when those parts are touched are described here (136-37) as well as in the earlier chapter (XVIII. 47-50).

The King's seat is right in the centre on a fine stone; he sometimes indulges in a bath, sometimes enjoys the play of water from these manifold contrivances, the *Jala-śilpas*, sometimes listens to music and watches dancing here, and, particularly in summer, the fountain is a necessity (139-141).

More specific descriptions of the four types of *Dhārāgriha* now follow: The main speciality of the first, the *Pravarshaṇa*, the shower, is that it pours down water. Strong figures of three, four or seven men should be set up, with curved tubes; the whole mechanism is filled with water which is poured out in different ways by these figures (142-46). Bhoja calls this shower-house a pseudo-cloud, *anukaraṇam ekam jalamucām* (148)—(Somadeva Sūri's commentator gives it the name *kriṭrīma-megha-mandira*)—a boon in summer and a feast to the eyes. Kālidāsa's reference to the yantra-dhārā-griha has already been noted but when he says in his *Meghasandēśa* I. 61 (*neṣyanti tvām sura-yavalayo yantra-dhārā-grihatvam*), that the celestial damsels on the Himālayas would scratch the cloud with their bangles and convert it into a yantra-dhārā-griha, he seems to know also the name of this type called after the cloud.

The next variety called *Pranāla* is two-storeyed with a single pillar or four, eight or sixteen, built like a *Pushpakavimāna* with decorative designs. At the centre below is a water-tank with a big lotus, its pericarp fashioned as the seat of the King; around are female figures looking at the lotus; when the overhead

tank is filled and closed, water is poured by the figures on the King sitting on the lotus seat.

The third, *Jalamagna*, is a chamber under water, the idea being that of the submarine abode of Varuṇa or Nāgarāja. A square chamber is built at the bottom of a big and deep water-reservoir, the approach to it being through a subterranean passage. A continuous flow of water above keeps the chamber completely cool and the whole reservoir is full of mechanical lotuses, fishes, birds etc. When resting in this chamber alone or in private company, the King can be seen only by select personal friends and urgent visitors of rank like other Princes or Ambassadors. (157-66).

The last type, *Nandyāvarta*, has, in mid-tank, a big flower-like structure; all around the central floral design, in mid-water, are placed low walls in Svastika designs, providing a sufficient screen as well as a passage, the purpose being to permit playing in the water the game of hide-and-seek (167-72).

The fifth main division of the *yantrādhikāra* was mentioned at the beginning as *Rathadolā*; Bhoja now takes it up. *Rathadolā* is a swing or a merry-go-round in which people ride in seats, and enjoy the pleasure of wheeling round. That merry-go-rounds were a common sight is seen also in descriptions like the one we find in the poem *Citrabandha Rāmāyana* of Venkaṭeśakavi (Tanjore Ms. No. 3772, Verse 6.) where the courtizans wheeling round in the *Dāru-yantra* in the palace courtyard are described by the poet as stars going round Mount Meru. Bhoja devotes as much attention to it as to the *yantra-dhārā-griha*; here too types are known with distinct names, but Bhoja's descriptions here, though detailed, are not as clear as in the case of the fountains. The varieties are called *Vasanta*, *Madanotsava*, *Vasantatilaka*, *Vibhramaka* and *Tripura*, (174) and each subsequent type is more elaborate and complicated in its mechanism than the previous one.

In the *Vasanta* type the yantra is planted in a dugout 8 cubits square and 4 cubits deep; both metal and woodwork are mentioned at the base of the yantra where the rotation-mechanism is fitted to a platform. A storey is to be raised on twelve posts; on the whole five machines are to be employed for the rotation, wheel acting upon wheel and the whole moving the storey, designed like a lotus and accommodating the whirling riders (175-87).

In the second, the *Madanotsava*, there is no dugout or underground construction; the storey on the main post provides only for four seats and a man standing below operates the machine (188-94).

In the third, the *Vasantatilaka*, two storeys are to be constructed, the second one with much decoration; the mechanism is fitted in the first floor and by the action of wheel upon wheel the top floor revolves (195-200).

The fourth, *Vibhramaka*, provides for increased accommodation and variety of motion. At the base here is a solid platform and a square structure with mechanism; over these is a floor with eight seats, and above these another round of seats; spoked wheels link up the whole erection; the speciality here is, each floor has its own different movements, creating, as the name implies, a complex of circular movements (201-8).

The last, *Tripura*, increases the tiers by one, justifying its name of three cities in air, each higher floor being of smaller dimensions; a large number of connecting links, small wheels and steps leading from one tier to the other are mentioned (209-18).

The most curious of the yantras described by Bhoja in this chapter is, of course, the one that rises and travels in the air. From the previous notices of this aerial machine only the barest details of its make-up could be gleaned. The only text that gives us some knowledge of its actual construction is this work of Bhoja. Firstly Bhoja mentions the main material of its body as light wood, *laghu-dāru*; its shape is that of a huge bird, *mahāvihāṅga*, with a wing on each side. The motive force is then explained: In the bowels of the structure, below, is to be a fire-chamber with mercury placed over a flame. The power generated by the heated mercury, helped by the concurrent action of the wings which are flapped by a rider inside, makes the yantra go up and travel far (*dāra*) (95-96).

A heavier (*alaghu*) *Dāru-vimāna* is then described (97-98); it contains, not one as in the previous case, but four pitchers of mercury over iron ovens. The boiling mercury ovens produce a terrific noise which is put to use in battle to scare away elephants; by strengthening the mercury chambers, the roar could be increased so that by it elephants are thrown completely out of control. This specific military use of aircraft against elephants tempts one to suggest that the *Hasti-yantra* advocated by Kauṭilya against elephants was something like the heavier *Dāru-vimāna* described by Bhoja.

लघुदारुमयं महाविहङ्गं दृढसुश्रितनुं विधाय तस्य ।
उदरे रसयन्त्रमादधीत ज्वलनाधारमतोऽस्य चाग्निपूर्णीम् ॥
तत्रारूढः पूरुषस्तस्य पक्षद्वन्द्वोच्चालप्रोज्ज्वलितेनानिलेन ।
सुप्तस्यान्तः पारदस्यास्य शक्त्या चित्रं कुर्वन्नम्बरे याति दूरम् ॥
इत्यमेव सुरमन्दिरतुल्यं सञ्चलत्यलघु दारुविमानम् ।
आदधीत विधिना चतुरोऽन्तस्तस्य पारदभृतान् दृढकुम्भान् ॥
अयःकपालाहितमन्दवह्निप्रतप्ततत्कुम्भभुवा गुणेन ।
व्योम्नो भगित्याभरणत्वमेति सन्तप्तगर्जद्रसराजशक्त्या ॥

वृत्तसन्धितमथायसयन्त्रं तद्विधाय रसपूरितमन्तः ।
उच्चदेशविनिधापिततप्तं सिंहनादसुरजं निदधाति ॥
स कोऽप्यस्य स्फारः स्फुरति नरसिंहस्य महिमा
पुरस्ताद्यस्यैता मदजलमुच्चोऽपि द्विपघटाः ।
मुहुः श्रुत्वा श्रुत्वा निनदमपि गम्भीरविषमं
पलायन्ते भीतास्त्वरितमवधूयाङ्कुशमपि ॥

95-100

There may be some lacunæ in the description, and Bhoja does not fail to mention that some vital knowledge is kept back as a secret, an idea which we noticed in the *Brihatkathā* story also. It is, however, clear that mercury vapour ought not to be confused as providing any lifting power; it was evidently converted into mechanical power, and the machine must have risen, as is expressly stated here, and implied by the mention of its cock-shape in the *Brihatkathā* story, by the flapping of the wings, and further movement must have been due to the manipulation of the wings and the flow of air itself, on the analogy of the flight of birds.³⁷

An important point to be noted in Bhoja's treatment is that he discusses the views of some earlier writers (XXXI.6), expressly mentions some of his yantras as having been described by the ancients (84), and refers to *yantra-śāstra-adhikāra* as comprising five sections (88). All this implies the existence of a technical literature on the yantras. Daṇḍin, we noted, mentioned earlier authors on the subject, Brahma, Indra and Parāśara.

A further point of interest is that Bhoja speaks of some of these as having been seen and described on first-hand knowledge of them (*yantrāṇi yāni drishṭāni*, 82).

The references to yantras found in highly reputed works cannot be held suspect; and facts mentioned by one writer receive confirmation from another.

Further, the consistent reference to a particular people, the Yavanas, as handling the *Ākāśa-yantras*, not only adds realism to these descriptions, but also sets us on an inquiry into the history of yantras in the civilizations with which India came into close contact, the Persian, Greek and Arab. The evidence collected by Elliot and Oppert on the use of fire and war machines by the Greeks and the Arabs has already been referred to.

Reference may also be made to Penzer and the evidence collected by him on the Greeks and automata. In his translation of the *Kathāsaritsāgara* ("Ocean

³⁷ Cf. Roger Bacon, *op. cit.* :—"Also flying machines can be constructed so that a man sits in the midst of the machine revolving some engine by which artificial wings are made to beat the air like a flying bird...." (THORNDIKE, *op. cit.*, Vol. II, pp. 654-5).

of Story") Vol. III (1925), in a separate Note (pp. 56-59) on the automatic toys of Somaprabhā and the city of machines of the architect Rājyadhara, Penzer has presented very valuable information. According to him,

"the first scientific inventor of such objects" as are mentioned in the *Kathāsaritsāgara*, "was probably Archytas (c. 428-347 B.C.), the Greek philosopher of Tarentum. . . . He constructed a kind of flying machine, consisting of a wooden figure balanced by a weight suspended from a pulley, and set in motion by "hidden and enclosed air." The tenth book of the *De Architectura Decem* by Vitruvius, the Roman architect of the time of Cæsar, is wholly devoted to mechanical inventions of all kinds: water-raising contrivances, various entertaining things like birds singing by means of water-works, figures that drink and move and so on.³⁸ Hero of Alexandria of c. 100 A.D. invented numerous complicated drinking animals and wrote also treatises on them, like *Catoptrica*, *Pneumatica* and *Automatopoietica*.

Many of his inventions³⁹ have correspondences to those mentioned by Somadeva and Bhoja: mechanical birds singing by the air driven through them by the force of water—which remind us that the musical devices of the *yantra-dhārā-griha* are worked ultimately by water, statues pouring out libations, dancing figures that revolve, those based on sun's heat or warm air, have echoes in our literature. Bhoja's automatic lamp has its parallel in the inexhaustible lamp in this treatise. The reference to many of these producing sound or acting by the principle of stopped and released air, and air expanding by heat, remind us of Bhoja's identical statements in the *Samarāṅgaṇasūtradhāra* (XXXI. 40-41 and 78).

संगृहीतस्य तापाद्यैः यानि पावकजन्मनि ।
प्रकीर्तितानि तान्येव भवन्ति पवनोद्भवैः ॥
प्रेरितः संगृहीतस्य जनितश्च समीरणः ।
आत्मनो बीजतां गच्छत्येवमन्यत् प्रकल्पयेत् ॥
निरुद्धमुक्तस्य वशान्मरुतो यन्त्रभङ्गिभिः ।
याश्चेष्टा दिव्यमानुष्याः ता एवात्र न केवलम् ॥

The prevalence of such automata and robots in the Islamic countries is shown by Penzer but the references cited by him are later than the Sanskrit works discussed here; for instance, Al-Jazari's *Book of the Knowledge of Ingenious Contrivances* was written in 1206 A.D.

³⁸ THORNDIKE, *op. cit.*, Vol. I, p. 188.

³⁹ *Ibid.*, pp. 189-193.

Not only these corroborative data from the side of the Yavanas, but also some of the details mentioned in our works with reference to the *Ākāśa-yantras*, such as seating capacity, travelling range, difference in speed, accidents, materials and methods of manufacture and various Kings' curiosity about and fondness for these show that we are no longer in the regions of the Puranic *Pushpakavimāna*, but in the world of actual fact.

The tradition pertaining to this lore was, however, neglected and lost. The vogue that these mechanical contrivances had over a sufficiently long period was indeed enough to foster the development and spread of mechanical technology on a national scale, but it was just like the civilization of this country not to have taken to it on such a scale. The reason is not far to seek: the religious and spiritual preoccupation was such that machines, which in other countries ushered in a civilization that increasingly became materialistic in outlook, were harnessed in this country to reinforce the idea of God and Spirit.

If material yantras did not take root or multiply, spiritual yantras, which took one to still higher regions, developed and multiplied on a vast scale. And even writers who actually dealt with the yantras, like Somadeva and Bhoja, saw in the machine operated by an agent an appropriate analogy for the mundane body and senses presided over by the Soul, and for the wonderful mechanism of the universe, with its constituent elements and planetary systems,⁴⁰ requiring a divine master to keep it in constant revolution.

जडानां स्पन्दने हेतुं तेषां चेतनमेककम् ।

इन्द्रियाणामिवात्मानमधिष्ठातृतया स्थितम् ॥ K. S. S. VII. 9.14

भ्राम्यद्दिनेशशशिमण्डलचक्रशस्त-

मेतज्जगत्त्रितययन्त्रमलक्ष्यमध्यम् ।

भूतानि बीजमखिलान्यपि संप्रकल्प्य

यः सन्ततं भ्रमयति स्मरजित् स बोऽव्यात् ॥ S. A. S. Dh. XXXI. 1.

And, as early as the *Gilā*, the machine became an apt simile for man being but a tool in the hands of the Almighty that sits in man's heart and by His mystic power makes man not only move but also delude himself into the notion of his being a free or competent agent.

ईश्वरः सर्वभूतानां हृद्देशेऽर्जुन तिष्ठति ।

भ्रामयन् सर्वभूतानि यन्त्रारूढानि मायया ॥

⁴⁰ Cf. Vitruvius: "...all machinery is derived from nature, and is founded on the teaching and instruction of the revolution of the firmament."