I

TIME MEASUREMENT AND INCENSE IN EAST ASIA

I

Early East Asian time measurement

The measurement of time has preoccupied mankind from its earliest civilizations in all parts of the world, although not always for the same purpose or to the same degree. As man's needs and knowledge increased, so did his awareness of the meaning of time. In the Far East as in the Western world, man learned from observing the common phenomena of nature, notably the movements of the sun, the moon, and the stars.

Observation of celestial phenomena, such as the periodicity of the sun and moon, brought even greater cognizance. Myths and superstitions relating to time were created, which in turn gave rise to cults and religions evolving from special rites designed to keep deities benign.

The Chinese developed the legend of P'an Ku, for example, the first Adam who devoted eighteen thousand years to creating the universe by chiseling stars and planets from the cliffside of Chaos. It was from the beginning of that period, tradition claims, that the Chinese began the measuring of time.[1]

The duration of day and night was ascribed to the periods of waking and sleeping of the Great Dragon, whose breathing regulated the winds and the seasons. The day's division into hours was derived from the legend of the Ten Chariots of the Sun, drawn by six dragon horses and driven by the mother of the sun, which raced after one another across the sky. Each of the chariots represented one hour of the day, and evil befell anyone who viewed more than one at the same time.

Celestial phenomena were explained by the legends describing them, such as the tale of the Excellent Archer who shot down nine of the ten suns with his magic bow, and the story of the Cowherd and the Weaving Girl which explained the Milky Way. The myths and legends gradually became interwoven with religions that evolved, influenced, and eventually became part of the philosophic considerations of scholars.[2]

These exotic practices led from the construction of megalithic monuments

[1] C. A. S. Williams, *Encyclopedia*, pp. 309–11; S. W. Williams, *Middle Kingdom*, vol. 2, pp. 137–42.
[2] C. A. S. Williams, *Outlines*, pp. 121, 273–74, 347.

relating to the directions of sunrise and moonrise and their settings, to the production of astronomical models which illustrated the sun's annual cycle, all designed to reflect the orderly sequence of celestial events – heliacal risings and settings, the moons, and equinoxes and solstices. After the passing of centuries and not long before the beginning of the Christian era, there occurred almost simultaneously in China and Greece the development of astronomical knowledge which resulted in greater awareness of time and provided the first means for its measurement.

As man first attempted to measure time, the tools at his command were primitive in the extreme – the shadow cast by a sunlit tree or a vertically erect pole led to the invention of the sundial. Later, the realization that the flow of water could serve as measurement brought about the invention of the clepsydra or water clock.

With increasing awareness of the natural world came the realization that time provided a means by which order was furnished to all organic and human experience. Man learned to consider time in terms of two basic units – the interval and the epoch, the first to measure duration and the second to measure location in time. Thus, time became a subject of man's philosophical considerations long before he attempted to harness it for practical use.

Chinese philosophers speculated about time and its content from very early periods, and definitions and discussions of time and its relation to space are to be found in Chinese writings as early as the fifth century B.C. By the first century the Bureau of Astronomy had become an important office of the civil service, concerned with celestial observation and continued development of the calendar. Consciousness of time increased among Chinese intellectuals as they acquired more and more new knowledge about the natural world.[3]

Inevitably from early times man applied his senses for measurement of time, first his sight and then his hearing. Much later, with the advent of the mechanical clock, he applied other senses. The sense of touch was utilized with the eighteenth-century French invention of timepieces designed for the blind so that the current hour could be determined by raised knobs opposite the relevant numerals. In the same period was developed the horological oddity, admittedly without wide application, of a clock on which the hour numerals were identified by the sense of taste.

It was in the countries of the Far East that the fifth sense – the sense of smell – was first applied for the measurement of time by means of burning incense. Incense is believed to have come into use in China as part of Buddhist religious rites which had been transmitted from India, following the translation into Chinese of Indian Tantric scriptures by the Indian Buddhist monk Amoghavajra.

[3] Needham, *Time*, pp. 1–52.

In the Western world the use of incense has generally been limited to religious or cult practices, whereas in East Asian countries it served many other practical uses as well. It is consequently not surprising to discover that it was widely utilized also as a means of measuring time in the palace, government office, Buddhist temple and scholar's study.

The awareness of time achieved by Chinese philosophers, scholars, and the court bureaucrats from astronomical studies and activities, however, did not extend to the common people engaged in everyday pursuits. The latter's awareness was related only to their daily activities, and consequently had little meaning for them. It was observed by foreign travelers during the eighteenth and nineteenth centuries that unlike many of the common people in Western countries, those in the Far East remained comparatively unconcerned with the time factor. Punctuality did not appear to be a characteristic of the people, nor in fact was it considered to be a desirable trait. Again and again visitors to China reported that the Chinese appeared to express no need to know the time except approximately, demonstrating a lack of concern that has persisted to modern times. However, the outlook of the man in the street has probably varied considerably from one historical epoch to another.

For the populace time periods were related to common experiences, such as the time required to drink hot tea, to consume a bowl of rice, to travel a specified distance, or to burn a stick of incense.[4]

An expression frequently encountered in Chinese writings is "the time of burning an incense stick" (*i chu hsiang ti shih hou*), a common phrase used to indicate the lapse of a time period.[5]

It is conceivable that because of its wide use, the burning of a stick of incense became in fact a common unit of measure, and that it was in fact a consequence of this practice that eventually led to the marking of an incense stick with graduations of the time divisions required for its consumption. The incense stick came into use at every level of daily life. In the time of Cheng Ho and before, for example, the incense stick was used to time watches kept at sea, and mariners changed their compass direction only when a number of these had burned to the end.[6]

Among those commenting on the apparent lack of concern for time were American residents in China in the mid-nineteenth century. Clocks in public buildings, particularly railroad stations, appeared never to register the time with

[4] J. D. Ball, *Things Chinese*, p. 713.
[5] *Chung-shan ta tz'u tien i tzu ch'ang pien*, p. 472. Communication to the writer from Prof. Yang Lien-sheng, November 6, 1959.
[6] Needham, *Science and Civilisation in China*, vol. 4, part 3, pp. 564, 570, 583; these volumes are referred to hereafter as *SCC*.

any degree of accuracy. When one of these public clocks malfunctioned, no attempt was made to repair it; instead a new clock was added to the wall and the inoperative ones allowed to remain. Travelers noted seeing walls of some public offices and railroad stations covered with a number of clocks, most of them no longer functioning, the others inaccurate. An American doctor living in China in the mid-nineteenth century wrote, "... clocks are not often met with in China; they are generally confined to the public offices, where it is common to find half a dozen in a row."[7]

Robert K. Douglas, the British Museum's Keeper of Oriental Books and Manuscripts and Professor of Chinese at King's College, London, writing in the late nineteenth century, also commented on the apparent unconcern with precision time measurement:

> For the most part, ... even at the present day, Chinamen are dependent on the sun for their knowledge of the time of day. Happily for them, punctuality in all matters of daily life is foreign to their social system, and the division of the day into twelve periods, measuring two hours apiece, supplies with sufficient minuteness all that is required for fixing appointments and keeping engagements in that leisurely land. In some cities clepsydrae are used to mark the progress of time, and occasionally joss-sticks, which are carefully divided by the astronomical board into periods corresponding to the hours are kept burning for the same purpose. The advance from these rough contrivances to clocks and watches is as great as that from the native candles to kerosene lamps.[8]

Early in the twentieth century, another traveler commented that in Hong Kong, Macao and in the vicinity of the Treaty Ports "clocks are found in every shop and watches abound, but in many places there is no standard of correct time, and in places where there is, it is ignored extensively." A Westerner obviously annoyed by the attitude of the Chinese so different from that of his own culture, wrote:

> Time – but what idea has a Chinaman of time? Time does not enter into the essence of his ordinary conceptions of a day, or, at all events, the idea is so very vague that the conception of it seems but an inchoate one ... Life is not such a mad rush as with our feverish pursuit of wealth, a livelihood, or learning. Fix a time for an engagement with a Chinese, and he comes in half an hour late, or even two or three hours after, occasionally a few days later than the day fixed upon, with no idea that he had done anything out of the way.[9]

More recently, Chiang Monlin described the wide dichotomy that existed in the sense of time of the privileged class as compared with that of the peasants:

> Clocks were unnecessary – for what is the use of keeping exact time in a village? What

[7] Magowan, "Modes," p. 336.
[8] Douglas, *Society*, p. 313.
[9] J. D. Ball, *Things Chinese*, p. 709.

difference would it make to be two or three hours too late or too early? The country folk counted time in days and months, not in minutes or hours.[10]

The same indifference to precise measurement of time prevailed also in Japan. Sir Ernest Satow, who was attached to the British Mission in Japan during the years of its revolution which restored the Mikado in the mid-nineteenth century, wrote:

> In those days neither clocks nor punctuality were common; and, as the hour altered in length every fortnight, it was very difficult to be certain about the time of day, except at sunrise, noon, sunset and midnight.[11]

For an understanding of how incense first came to be applied for the measurement of time in the Far East and of how it was developed for both religious and community purposes, it is necessary first to review briefly the evolution of time measurement in East Asia. Then, consideration must be given to the development of incense from its function in primitive religious rites to its pervasive presence in daily life in East Asia, a presence which had no counterpart in the Western world.

The published history of time measurement in the Far East has been fragmentary at best. Research in recent years has produced excellent published studies of scientific time measurement in early China, particularly the remarkable astronomical instruments and clocks of the Chinese imperial court and of Korea. There is, however, room for further study. Meanwhile, the early history of time measurement in Japan remains to be studied and reported. Most neglected has been the story of time measurement among the common people of Japan.[12]

For centuries communal time measurement was achieved in the Far East by three means – sundials, clepsydrae, and incense timekeepers.[13]

The moving shadow cast by a sunlit gnomon (from the Greek word *gnomon* meaning "interpreter" or "the one who knows") has measured the sun's daily journey across the sky and divided the daylight hours from time immemorial in every early civilization. Through the centuries the gnomon has assumed many forms, from the primitive denuded tree trunk or erect pole in an open area, or megalith in Majorca, to the shining metal stylus of a Ming fire-gilt monumental equatorial dial of a Chinese palace (Fig. 1).

In Egypt the sundial appears to have been preceded by the shadow clock, an

[10] Chiang Monlin, *Tides*, pp. 34–35.
[11] Satow, *A Diplomat*, quoted in Robertson, *Evolution*, p. 193.
[12] Needham, The Wilkins Lecture; The Henry Myers Lecture; *SCC*, vol. 3; Needham *et al.*, *Heavenly Clockwork*; Needham *et al.*, *Hall of Heavenly Records*.
[13] For the most comprehensive accounts of Chinese sundials, clepsydrae, sand clocks, and the astronomical clocks of Su Sung, see Needham *et al.*, *Heavenly Clockwork* and Needham, *SCC*, vol. 3.

example of which was recovered from an Egyptian burial of the fifteenth century B.C. Other time-reckoning devices may have existed there even before that period.[14]

A sundial, in the unusual form of a refracting instrument, is described in the Second Book of Kings of the Old Testament. The sundial was made in about 771 B.C. by Uriah, the priest of Jerusalem, for Achaz, the eleventh ruler of Judah. It was mentioned again in the thirteenth year of the reign of Hezekiah, the son of Achaz.[15]

The earliest knowledge of sundials among the Greeks is attributed by tradition to Anaximander of Miletus in the sixth century B.C. This tradition was partially reinforced in the fifth century B.C. in a statement by Herodotus that the concept of the sundial had come to Greece from the Babylonians. The gnomon had in fact been known to the Greeks from an earlier period, used for solar and astronomical observations. The sundial evolved over the centuries in various forms, and continued in use long after geared clockwork timetelling devices came into being.[16]

The earliest form of timekeeper noted in East Asian countries appears to have been the most primitive type of the sundial. The *K'ao kung chi* chapter of the *Chou li* (Records of the Rites of [the] Chou [Dynasty]) attested to "the installation of a straight pole to observe its shadow."[17]

The use of the gnomon is mentioned also in the *Chou pei suan ching*, an ancient work on mathematics attributed to c. 1100 B.C.[18]

Gradually more sophisticated forms were developed. One of the earliest known surviving Chinese examples is an equatorial dial consisting of a stone disk elevated at an angle on a pedestal, with a bronze pin penetrating it at the center and projecting on both sides. The upper side of the pin points to the North Pole and the lower end of the projection to the South Pole.[19]

A sundial (*kuei piao*) is described in the writings of the Shu period of the Three Kingdoms Dynasty. Relics of two examples, probably of the Western Han period, were reported. Of primitive form, they included indications for compass directions. Their primary purpose may have been for the measurement of time only, and the possibility exists that they were introduced from other countries, and were not indigenous to China.[20]

[14] Priestley, *Man and Time*, pp. 22–24, 143–48.
[15] The Bible, Book of Kings II, 20:9–11, Book of Isaiah, 38:8; Earle, *Sun-Dials*, pp. 391–95; Sachse, "Horologium," pp. 21–30.
[16] Gibbs, *Greek and Roman Sundials*, pp. 3–11, 66–88.
[17] *Chou li*. Translation by E. Biot, *Le "Tcheou-Li" ou "Rites des Tcheou"*; Needham, *SCC*, vol. 3, pp. 28 b, 290–92.
[18] *Chou pei suan ching* (Arithmetical Classics of the Gnomon and the Circular Paths of Heaven), sixth century B.C. – ante A.D. 80; Needham, *Heavenly Clockwork*, p. 19, fn.
[19] Maspero, "L'Astronomie," pp. 267–356.
[20] Kim Yong-Woon, "Origins," pp. 4–11.

Listed in the bibliography of the *Ch'ien Han shu* is a "*Sundial Book*" (*Jih kuei shu*).[21] The same work mentioned sundials in relation to a gathering of calendar experts who assembled in about 104 B.C. It described the manner in which the true east and west points were established, after which "gnomons were raised and clepsydrae activated (*li kuei i hsia lou k'o*)." The calendar experts marked out the twenty-eight *hsiu*, and fixed the first and last days of each month, the equinoxes and solstices, the phases of the moon, as well as the movements and positions of the heavenly bodies.[22]

Two surviving sundials (*ts'e ching jih kuei*) attributed to the Han period have inscriptions which appear to be identical. In each instance the inscription appears only upon the upper surface and is in the form of a diagram consisting of two circles with the annular space divided into equal segments of hundredths along the circumference. At the center is a socket for a fixed gnomon, and at the intersection of the lines with the outer circle are sixty-nine sockets for the insertion of a movable gnomon, the shadow of which would coincide with that of the fixed gnomon.[23]

In later periods monumental sundials were erected in palace courtyards and other public places for the use of the court and the public. A number of these have survived (Fig. 2).[24]

Sundials were mentioned also in literary works. As an example, the T'ang poet, Li Ho (A.D. 790–816), at one time Supervisor of Ceremonies in the Court of Imperial Sacrifices in the T'ang capital of Ch'ang-an, became dissatisfied with his position. In his poem, "After Days of Rain in the Ch'ung-i District," he wrote longingly of his distant mountain home, describing how

> The Southern Palace is darkened by ancient blinds,
> Its sundials blank beneath a watery sun.[25]

That the time measured by the sundial was not always the same due to the irregularity of the apparent motion of the sun through the sky was known from ancient times to the Babylonians and the Greeks and to the Chinese. The sun moves through the sky sometimes faster and sometimes slower than its average motion. The irregularity is due to two circumstances, the eccentricity of the earth's orbit, and the difference between the planes of the equator and the ecliptic.

[21] Yin Hsien (first century B.C.) assisted in editing and classifying the books brought together by the emperor from all parts of the Chinese empire. Needham, *SCC*, vol. 3, p. 302; Giles, *Dictionary*, pp. 945–46.
[22] *Ch'ien Han shu*, (History of the Former Han Dynasty), ch. 21A, p. 16 b. Needham, *SCC*, vol. 3, p. 302; Needham, *Heavenly Clockwork*, pp. 200, 204.
[23] Yetts, *Cull Chinese Bronzes*, pp. 150–65; Neeham, *SCC*, vol. 3, pp. 302–9.
[24] Needham, "Astronomy," pp. 67–82; Needham, *SCC*, vol. 3, pp. 302–7.
[25] Frodsham, *Goddesses*, p. 110.

As a consequence, the greatest positive difference between clock-time and sundial-time is $14\frac{1}{2}$ minutes occurring in February and the greatest negative difference of $16\frac{1}{2}$ minutes occurs in November, which is known as "the equation of time." Li Ch'un-feng (fl. A.D. 620–680) developed algebraic methods for determining it in preparing the Lin Te calendar of 665. The consequent inequality of the four seasons – the time passed between the solstitial and equinoctial points – was realized by the ancients. In the eleventh century the discrepancy, of approximately one Chinese quarter (*k'o*) undoubtedly became apparent in the use of the clepsydra or water clocks. It is possible also that the discrepancy could have been detected in the use of the "perpetual lights" or oil lamps used as timekeepers in temples. As reported by Fan Shun-ch'en in the *Shan chu hsin hua* of c. 1360, in these the oil supply was measured by *k'o* revealing a discrepancy between the time measured by the oil lamp and the sundial.

Because sundials functioned only in fair weather and in sunlight, it was inevitable that other forms of timekeeping would be provided for measurement of the hours in which sunlight was absent. Thus was born the water clock (clepsydra). It was not a Chinese invention, having existed in both Egypt and Babylonia for centuries before the early Shang period. The advent of the clepsydra in China is attributed by some sources to the legendary Yellow Emperor, Huang Ti, who began his reign in 2698–2695 B.C. Tradition claims that he had twelve bells cast to correspond to the twelve moons to indicate the seasons, months, days and hours.[26]

The *Chou li*, the oldest surviving record of institutions of the period and concerned primarily with customs and ceremonies, assigns the invention of this primitive form of timekeeping to the year 2356 B.C. in the reign of Yao. It reports that efforts were then being made to mark the revolutions of the planet Jupiter. It was ordered that the hours of the night be divided into intervals, and that the people be informed of them by public display of wooden tablets, each inscribed with the character for the current hour. It was further noted that the intervals were measured by means of water clocks, each of which had a large hollow basin into which water dripped. The interior of the basin was marked with the divisions of the hours and their parts, and was illuminated by lamps so that the divisions remained visible throughout the night.

In the Early Chou Dynasty a court functionary named Ch'ieh Hu Shih was designated to maintain the clepsydrae of the Duke of Chou, brother of the first ruler of the family, who was said to have been the first to provide a means of heating for clepsydrae to prevent the water from freezing during the winter months.[27]

[26] Needham, *SCC*, vol. 3, pp. 123, 202; Giles, *Dictionary*, pp. 338–39.
[27] Gaubil, *Histoire*, cited in Planchon, "L'Heure," p. 194.

Generally the clepsydrae were made in the form of a series of water tanks ranging in number from two to four of varying shapes and sizes. An early description occurs in the *Lou shui chuan hun t'ien i chih* (Apparatus for Rotating an Armillary Sphere by means of Clepsydra Water) Chang Heng.[28]

Early allusions to clepysdrae in Chinese writings occur also in the *Shih chi* in connection with the career of a military figure in the period of the Warring States. Mei Yao-ch'en, a poet of the Northern Sung period, wrote of the simple form of the inflow clepsydra with two vessels, in common use in rural districts:

> The astronomers know of the rising and setting of stars,
> No error they make in predicting the heat and the cold;
> But the farmer too keeps time with his rustic pots
> And grudges the loss of a single inch on the dial.
> The drops of his sweat match those of the dripping clepsydra,
> The swatches of his cutting advance like the shadow itself.
> Who could disdain or regret this life-giving labor?
> Who can snatch back an hour from the realm of the past?[29]

In time clepsydrae were improved by using four tanks with spouts shaped like mouths of dragons and other animals from which the water was emitted. In the Later Han period, about A.D. 164, clepsydrae were constructed also in other forms, including some made as spheres featuring signs of the zodiac to mark the time divisions. In the Northern Wei Dynasty as noted by the Taoist Li Lan in his *Lou k'o fa* preserved as part of the encyclopedic *Ch'u hsüeh chi*, water, the common fluid in clepsydrae, was replaced with mercury.[30]

Yet another form of the water clock incorporated a wooden figure attached to a rod which floated in a water tank, with its outstretched hand pointing to the current hour on a vertical scale. There is considerable similarity between this device and the water clock described in the Western world by the first-century Roman architect and engineer, Marcus Vitruvius Pollio.[31]

The earliest known depiction of a Chinese clepsydra is found in *Liu ching t'u* (Illustrations of Items Mentioned in the Six Classics), a twelfth-century work by

[28] Needham, *SCC*, vol. 3, p. 320; Needham, *Heavenly Clockwork*.

[29] Wang Chen, *Nung Shu*, ch. 19, 20a *et seq.*; Needham, *SCC* vol. 3, pp. 315–20. Mei Yao-ch'en's dates are also given as 1002–1060. A native of Wan-ling in Anhwei, he inherited official rank. After presenting an account of his poetic abilities at the Imperial Academy, he rose to the position of second-class secretary, and was appointed to the commission to prepare a new history of the T'ang period. Giles, *Dictionary*, p. 579.

[30] Planchon, "L'Heure," p. 194; Needham, *SCC*, vol. 3, pp. 326–27.

[31] Vitruvius, *Architecture*, 1673, 2nd edition, 1684. Although there are many editions of this work from the fifteenth century to the present, this is considered to be the earliest of merit. Clepsydrae are described in Book 4, ch. 4; Diels, *Antike Technik*, p. 213.