

SAW Conference

Mathematical Practices in relation to the Astral Sciences

March 26-27-28 and 30-31, 2015

Quantities and Measurements Units

March 26th, 2015

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Simulating Clepsydra: Two Methods of Time Measurement for Military in Ancient China

Abstract - Clepsydra (漏刻) was the most important time measurement device in ancient China. To measure time, Clepsydra required two basic components: Pots (壺) and Scale-rulers (漏箭). The Pots included Water-dropping Pot (泄水壺) and Water-receiving Pot (受水壺), which allowed the water to flow continuously just as time elapsed. The Scale-rulers were made of wood or bamboo, floating on the water in the Water-receiving Pot. When the clepsydra was working, people could evaluate the rising of the water level through the graduation on the Scale-ruler, thus the elapsed time could be quantified.

However, the clepsydra could not be used to measure time separately, and the operation was closely related to the official calendrical systems. When ancient Chinese used the clepsydra to measure time, a whole day was often divided into two parts: day time and night time. When night time ended, day time began; whilst when day time ended, night time began. Therefore there were two starting points for time measurement: sunrise and sunset. This operation was quite different from the clocks and watches we are using nowadays. Indeed, since the cycles of sunrise and sunset - the time starting points - changed annually, ancient Chinese had to change different scale-rulers to adapt it. A Chinese official calendrical system (曆法) was a special astronomical knowledge system that included series of data about different lengths of Days & Nights (晝夜長短) or different times of Sunrise and Sunset (日出入時刻). This is why the ancient Chinese changed scale-rulers of clepsydra.

Besides clepsydra, ancient Chinese also developed many methods for time measurement. In this paper, two procedures evidenced in military documents are introduced : Pace-counting (數步) and Bead-counting (數珠) . While former researchers thought these methods were different ‘instruments of measuring time’ for the military in ancient China, this paper aims at demonstrating that they were the simulations of the clepsydra. And according to the data in the original texts, the two methods had to be operated with the length of days & nights, provided by the official calendrical systems.

The Pace-counting was recorded in *Taibai Yinjing* (太白陰經 *The Yin book for Venus to Overwhelm the enemy with strategies*, ca. 8th century), in the Tang dynasty, and many later military documents copied this text. It is assumed that the operator could walk 200 *li* (里) constantly in a whole day’s time, which contained 100 *ke* (刻) in ancient China. Therefore, the operator’s walking speed was 2 *li* per *ke*. Another military document of Ming dynasty, *Zhanshou Quanshu* (戰守全書 *Encyclopedia of attack and defense*, ca. 1628 ~ 1644) used the same method.

The Bead-counting was first mentioned in *Wujing Zongyao* (武經總要 *General outlines of different military canons* ,1044) , from the Song dynasty, and recorded in *Jixiao Xinshu* (紀效新書 *New treatise on military efficiency*,1560) from the Ming dynasty. It also required a whole day’s time to be 100 *ke*, and the operator shifted a string of beads at a uniform speed while walking. While one had been walking a pace, he shifted one of 740 beads of the string by his fingers. In one *ke*, he could shift a few more than 740 beads and walk as the same number of paces. So the operator would finger 74700 beads and walk 74700 paces in a whole day.

Pace-counting and Bead-counting were relatively simple and could be operated easily in the military. For the two methods to be used, starting points for time measurement, such as sunrise and sunset, were also required and they changed annually. *Taibai Yinjing* (太白陰經) offered the night length of 12 Minor Solar Terms (中氣 *Zhongqi*). In this paper we provide evidence showing that lots of data were from the Calendrical System Yuanjia (元嘉曆, 445) and the Calendrical System Daming (大明曆, 510). The data provided by *Zhanshou Quanshu* (戰守全書) for the night length at Spring Equinox, Summer Solstice, Autumnal Equinox, Winter Solstice were from the Calendrical System Datong (大統曆,1385) . The *Jixiao Xinshu* also mentioned the use of day & night time at different Solar Terms (節氣) .

With the idea of simulating clepsydra, ancient Chinese tried to walk and shift beads at a uniform speed. In fact, the process of counting paces and beads was very similar to the quantification of continuous water flow between the Water-dropping Pot (泄水壺) and Water-receiving Pot (受水壺) . While measuring time, the day & night time in the official calendrical systems, had to be taken into account. The principle behind this method, was the same as the changing Scale- rulers of clepsydra.

By looking at these cases we offer a new perspective on the understanding of ancient Chinese time measurement.