Relationship between Elephant Figure and Hydrostatic Principles of *Eth Pahana* in Dedigama

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Introduction

Kotavehera is located at Dedigama in Kegalle district, Sri Lanka and is known to have been the birth place of king Parakramabahu I (1153 – 1186 AD). After becoming a great king, Parakramabahu I built this *stupa* which is also known as *Suthighara stupa* to mark the place of his birth. Paranavithana quoting the works of H. W. Codrington in *Ceylon Journal of Science, Part G, Vol. 2*, confirms present day Dedigama is the ancient area known as the birth place of king Parakramabahu I (Paranavithana, 2001). Gunawardana also notes that the construction of 'eth pahana' could be dated in the 12th century AD with a fair degree of confidence (Gunawardana, 1983). Up to the end of Sinhalese Kingdom in 1815, Dedigama was a *Gabadagama* of the Kandyan kingdom. The paddy fields of the village have been set apart for the benefit of the sovereign. *Eth pahana* was excavated from the upper relic chamber of *Suthighara stupa* at Dedigama in 1951. Excavations of this *stupa* were carried out in 1947 and 1951 to determine the formations of the relic chambers. This relic chamber is one of the finest examples of how relics were deposited in a *stupa*. Consecutive excavations during the period followed have been able to give light to many theories and unearthed a large number of artifacts including the *eth pahana*. Two of these lamps similar in design were found buried in the relic chamber of the *stupa*, and are now available in Polonnaruwa gallery at Colombo National Museum. The lamps are of a hanging type with a unique design. This archaeological exhibit, gives an insight into the advanced state of technological development during the reign of king Parakramabahu I.

fig.1 *Eth pahana*

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This lamp is generally known as *eth pahana*, meaning that the lamp resembles the figure of an elephant. The *eth pahana* is a good example for an ancient artifact that used hydrostatic principle for its functionality. This lamp is an ingenious creation of an unknown craftsman. The construction material of *eth pahana* has been identified as bronze, which was a common material for many artifacts in this period of time according to Coomaraswamy and Godakumbura (Coomaraswamy, 1914; Godakumbura, 1964). The origination source of this article is not solidly established. But there are some supporting evidences to conclude that by 12th century AD, Sri Lankan artists possessed a significant skill in bronze casting technology. Rao quotes from a publication called *Kamikagama* which sites treatises of *Simhaladesa*, present Sri Lanka regarding the bronze work and Basham highlights an important school of bronze casting that existed in Sri Lanka, and produced work similar in style to those of South India (Rao, 1914; Basham, 1967). Based on these discoveries and the styles of art works available in the *eth pahana*, it could be concluded that this is a piece of local work.

Ancient Usage of Hydrostatic Principles

The investigations and scientific literature relating to ancient Sri Lankan micro scale hydraulic equipment are very rare. Sri Lanka possesses a well established macro scale hydraulic structural system developed approximately from 3rd century BC. This consists of reservoirs, distribution canals and most importantly the water flow controlling devices, known as *bisokotuwa*. The usage of hydraulic principles for the automated actions goes far back as 3rd century BC. Cotterell & Kaminga notes two works written by Philon of Byzantium in the 3rd century BC and one by Heron in the 1st century AD describing a remarkable number of applications on the siphon for water flow automation (Cotterell & Kaminga, 1990). Gorokov describes the operation of water based alarm clock devised by Plato [428-348 BC] in 4th century BC (Gorokov, 1987). The usage of water flow for time measurement dates back even further. An Egyptian water-clock was found at Karnak in 1904, and dates from the reign of King Amenhotep III [1415-1380 BC]. This was a tapered shape vessel, filled with water, which leaked out slowly from a small hole near the bottom. The time being indicated by the level of water remaining within the vessel.

It is recorded that soot and pieces of burnt wicks were in the oil container at the time of first finding. This prompted to identify *eth pahana* as a lamp and that identification continued to date. This identification has been supplemented by the findings of similar articles from India. Gunawardana quoting the work of D. G. Kelker in his book *Lamps of India*, notes seven similar lamps located in various parts of India (Gunawardana, 1983). In the light of above, it is worthy to consider the possibilities of using *eth pahana* for alternative functionalities transcending its use as a lamp.

Construction Features of *Eth Pahana*

This is a product of exquisite workmanship which reveals the skill, the aesthetic judgment as well as the sense of humour of its originator. This represents a remarkable combination in the craftsmanship of not only a masterly grasp of techniques of metallurgy and knowledge of fluid behavior inside the tubes, but also of a superb aesthetic judgment with well proportioned scales and dimensions.

Eth pahana points to a high level of proficiency achieved in metallurgy. It is evident that main elements have been produced in several parts before they were assembled together. It basically consists of a base, an elephant figure and a hanging arrangement. An internal cavity inside the elephant figure serves as a reservoir for oil. The production of the elephant figure itself presents a rather complicated technical problem since it had to be cast with an inner chamber for oil, with an inlet pipe through its foreleg and an outlet orifice through genital organ. Subsequently, the figure of rider, cast separately, was soldered onto the main body. The elephant figure filled with oil was to mount on the base. There is a special provision to clock the elephant figure to the base, in order to avoid any relative movements. The base is fixed with a flame creeper which is decorated with a *makara* head, at the point of connection to the base. A chain decorated with fine figures of dancers and drummers is attached to the flame creeper so that the whole assembly could be hanged.

fig. 2 Construction Features of *eth pahana*

Functionality of *Eth Pahana* with Hydrostatic Principles

The functionality of *eth pahana* is mainly based on hydrostatic principles. Gunawardana notes that this operation was based on 'hydrostatic principles' (Gunawardana, 1983). Figure of an elephant carrying a rider on its shoulder predominates the oil receptacle. The hollow of the elephant's stomach serves as a vessel and a reservoir for the oil, while one of the elephant's forelegs serves as a funnel for pouring in the oil. The elephant figure stands in the middle of a basin which can also be filled with oil. When the level of the oil in the basin goes down below the level of the hole in the foreleg of the elephant which serves as a funnel, a mechanical devise based on hydrostatic principles causes the oil to flow into the receptacle through the genital organ of the elephant, and the flow automatically ceases when the oil again reaches the level of the elephant's feet. Hence, there is a close relationship between the elephant figure of *eth pahana* and its functionality bound with hydrostatic principle. The elephant figure needs to be overturned and oil could be poured into hole in its foreleg sole, which will consequently fill the reservoir, R. Once this is correctly placed on the base, oil starts to flow from orifice, O as droplets. The rate of oil flow would have been greater than the rate of oil burned, thus making a resultant accumulation of oil in the container, C. The rising oil level will submerge the opening hole of

pipe P, at which point the oil flow through orifice ceases. This is perhaps the most noteworthy feature of this lamp as the outflow of oil from the reservoir R to the lamp base was to be used as the means of automatic controlling of the oil level at the container C.

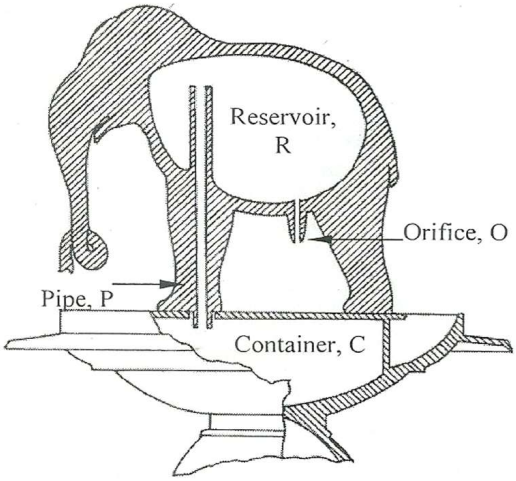

fig.3 Hypothetical sketch of *eth pahana*

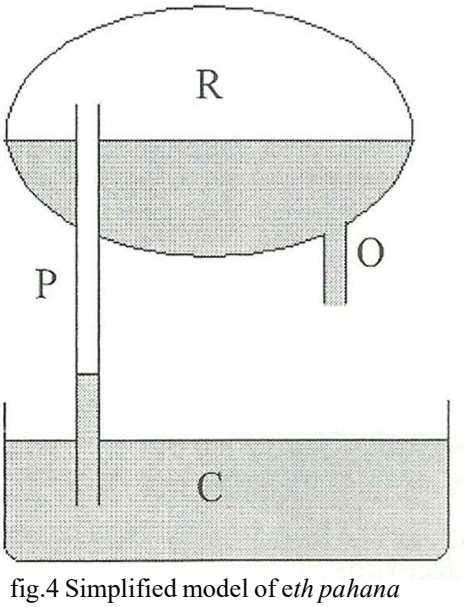

fig.4 Simplified model of e*th pahana*

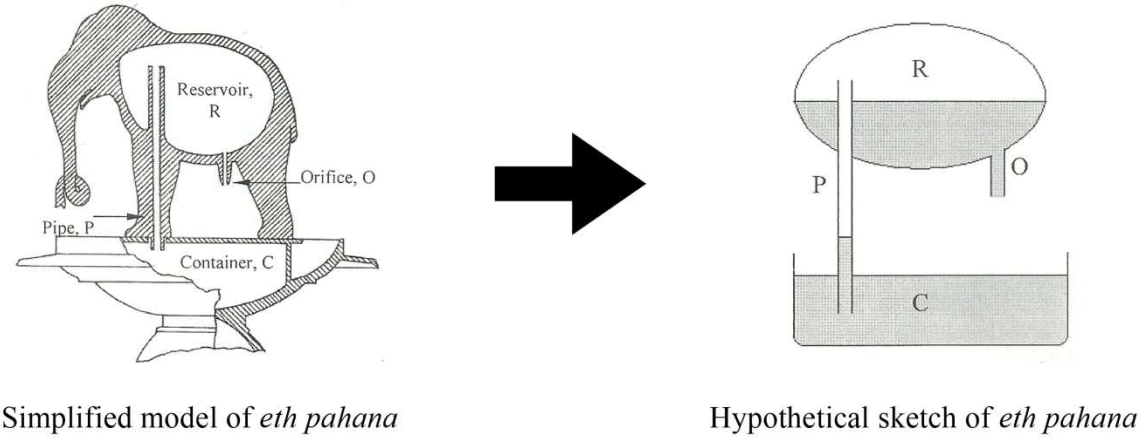

fig. 5 Relationship between elephant figure and hydrostatic principles

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